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ABSTRACT

This manual was conceived and developed by a team of teachers and subject matter experts from diverse areas and planned as a resource for teachers at the middle school and high school levels who are concerned with air pollution. Not intended as a syllabus or student text, it offers information and sample exercises which may be incorporated into a variety of subject areas together with data, charts, and illustrations which may be useful in classroom situations. The manual is essentially in four sections: (1) basic background in the scientific and societal origins of the problem of air pollution (scientific--composition and structure of the atmosphere, thermal energy and its effects, physical processes, local topographic effects, effects of cities, and interacting atmospheric subsystems; societal--historical perspectives, system of relations among individuals, long-range consequences, change and adaptation, and impetus for solutions); (2) treatment of the nature and scope of man's activities which contribute to air pollution, including primary industries, process industries, transportation, service industries, governmental activities, community activities, and recreational activities; (3) sample exercises in the sciences, social sciences, and humanities; and (4) bibliography. Each section is treated comprehensively. (BL)

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An Air Pollution Resource Manual for Junior High School and High School Teachers

Prepared under Grant No. GW5705
National Science Foundation
August 1, 1971

Robert G. Nurnberger, Director

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1400 Washington Avenue
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Prepared initially under a grant from the National Science Foundation, this manual was field-tested with forty middle and secondary school teachers from several disciplines, in an academic year institute which was also supported by the National Science Foundation. Staff members of the Commission on Science Education of the American Association for the Advancement of Science offered support and encouragement both at the inception and during the development of the project. Assistance of these groups and individuals is also gratefully acknowledged.

We particularly appreciate the efforts and enthusiasm of the writers and consultants listed below, who worked with us during the summer of 1970 writing session. Many of the consultants returned without compensation to instruct during the field test.

Special thanks are due Mr. Raymond Castillo, who continued with the project through the test and revision period, and is responsible for much of the narrative and laboratory exercise material in its final form.. Mrs. Sally Van Schaik created the very imaginative English exercises, and Mr. Roger Ward created the original drawings. Mr. Jackson Davis served as biblipgrapher to the writing team and organized the extensive bibliography which is part of this manual.

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Thanks are also extended to the students of the academic year institute, who used much of the material in their classes and offered helpful suggestions for its revision. Individual contributions of the class members to suggested exercises are acknowledged within the text.

Robert G. Nurnberger
August 1971

PREFACE

The manual was conceived by a team of writers and subject-matter consultants, which gathered during the summer of 1970, united in a common interest--air pollution. They maintained the following premises as a foundation upon which to center their activity:

1. Pollution problems are interdisciplinary in origin and solution.
2. Teaching in the area of environmental problems should not be delegated to an "ecology" course, but should be incorporated in all courses, at all levels of education.
3. Another way of incorporating the interdisciplinary approach is to orient teaching around real environmental problems.
4. An effective resource manual should be created with the active assistance of those persons who represent the potential users.

The above guidelines have become cliches of the environmental education movement, often spoken about, but seldom converted to action. With these guidelines a team of writers and subject matter experts were drawn from such diverse areas as economics, geography, atmospheric science, sociology, and law. The writers were primarily secondary and middle school teachers of English, social science, and science. The entire group exchanged ideas, evaluated written efforts, and learned from one another. The finished product is a manual of essentially four sections:

1. A basic background in the scientific and societal origins of the problem.
2. A treatment of the nature and scope of man's activities which contribute to air pollution.
3. Sample exercises in the sciences, social sciences, and humanities.
4. A bibliography.

The manual is planned as a resource for teachers at the middle school and high school levels. It is not intended to serve either as a syllabus, or as a student text. In the ideal sense, the teacher, or possibly groups of cooperating teachers, might select units which would be suggestive of activities corresponding to their respective areas of study. Additionally, data, charts, and illustrations have been incorporated, which may be useful in classroom situations. Many of the illustrative exercises have been highly structured as a guide for the person making his first attempts in this area of instruction. As each individual's program evolves, it is hoped that the teacher will use these exercises as a starting point for more locally adapted and open-ended procedures.

Finally, as a teacher resource, the manual presents ideas which have been utilized extensively at all levels--elementary school through undergraduate instruction in college. We hope that its utilization will extend also to the primary grades, since this area represents a critical period in environmental education.

Robert G. Nurnberger
Project Director

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I. The Atmosphere

A. Introduction

It is only possible to hypothesize about the original atmosphere of the earth and its evolution over the past 4 billion years. Since the atmosphere has been continuously polluted by natural geophysical and bio-physical systems prior to and during man's existence on earth, it is not possible to define an uncontaminated atmosphere. It is, however, possible to establish norms for the various constituents of the atmosphere and limits compatible with the maintenance of life systems. These limits are subject to change as we learn more about the dynamic balance of our ecosystem. In order to have a clearer understanding of the problem of air pollution, it is necessary to first know something of composition and dynamics of the atmosphere.

B. Composition and structure of the atmosphere

It is necessary to know the present dynamic system (in terms of its composition) in order to assess past changes and project possible future changes. A typical clean, dry atmosphere contains 78.09% nitrogen, 20.94% oxygen, with the remaining 0.97% consisting of small amounts of carbon dioxide, neon, helium, argon, krypton, and xenon by volume. Small amounts of other inorganic and organic gases are found in the atmosphere varying with time and place. Water vapor is present, varying in concentration up to 3-4%. Nitrogen, oxygen, argon, carbon dioxide, neon, and helium are believed to remain essentially unchanged in these relative concentrations by volume, up to 50 kilometers (see table 1).

Until about five years ago, gases such as nitrous oxide,

TABLE 1

Composition of clean, dry air near sea level*

	Content	
Component	% by vol.	ppm
Nitrogen	78.09	780,900
Oxygen	20.94	209,400
Argon	.93	9,300
Carbon Dioxide	.0318	318
Neon	.0018	18
Helium	.00052	5.2
Krypton	.0001	1
Xenon	.000008	0.08
Nitrous Oxide	.000025	0.25
Hydrogen	.00005	0.5
Methane	.00015	1.5
Nitrogen Dioxide	.0000001	0.001
Ozone	.000002	0.02
Sulfur Dioxide	.00000002	.0002
Carbon Monoxide	.00001	0.1
Ammonia	.000001	.01

*From Cleaning Our Environment the Chemical Basis of Action, American Chemical Society Washington, D.C., 1969 page 24.

nitrogen dioxide, methane, sulfur dioxide, carbon monoxide and ammonia, were not even included in a table listing the composition of clean, dry air. Although these compounds are small in quantity, they are important because they represent gaseous pollutants added to the atmosphere. The average daily concentration, measured at street level in a large city, may exceed 15 ppm for carbon monoxide. Normal values for nitrogen dioxide are 0.09 ppm, and 0.111 ppm for sulfur dioxide. The average daily concentration is contrasted with government standards in Table 2.

Table 2

Concentration of Pollutant Levels

Component	Average Daily Concentration Measured at Street Level	Government Standards
Carbon Monoxide	greater than 15 ppm	9 ppm per 8 hrs.
Oxidants	.04 ppm	0.08 ppm per hour
Nitrogen Dioxide	.09 ppm	0.05 ppm
Sulfur Dioxide	.111 ppm	less than .03 ppm
Suspended Particulates	124 micrograms/ cubic meter (m^3)	less than 260 micrograms/m^3/24 hr
Hydrocarbons	2.5 ppm	0.24 ppm/3 hrs.

All of these constituents compose an atmosphere which is divided into various sectors (e.g. the troposphere, closest to the earth, the stratosphere, the mesosphere, and the thermosphere), based on physical properties.

Figure I presents the major divisions according to the I.U.G.G. 1960 proposal. The lowest layer of the atmosphere, from the earth's surface to the tropopause, is called the troposphere. This region varies in height from 17-20 kilometers in the tropics, to 8-10 kilometers in the polar regions. Within this region is produced all of our weather, and man's activities are primarily restricted to its limits. The temperature, pressure, and water vapor content decrease upward in this region. From the earth's surface to about 8 kilometers in the troposphere, the pressure decreases about 1 millibar per 10 meters.

The stratosphere has an isothermal lower layer. In its upper region, the temperature increases with elevation. This region is noted for its ozone, the production of which aids in depleting the incoming ultraviolet radiation, which damages living tissue. The horizontal dashed line at about 30 kilometers (in Figure I) is important, since 99% of the weight of the atmosphere is below this level. Our discussion will principally be involved with man's effect on the troposphere, with some reference to the stratosphere.

The mesosphere is a region in which the temperature decreases rapidly with height, reaching the coldest point in the atmosphere, approximately 178 degrees Kelvin, or about -94 degrees Celsius. In the thermosphere, the temperature increases rapidly at first, and then more slowly with height.

The uppermost region, known as the exosphere, begins at 600-

ATMOSPHERIC NOMENCLATURE

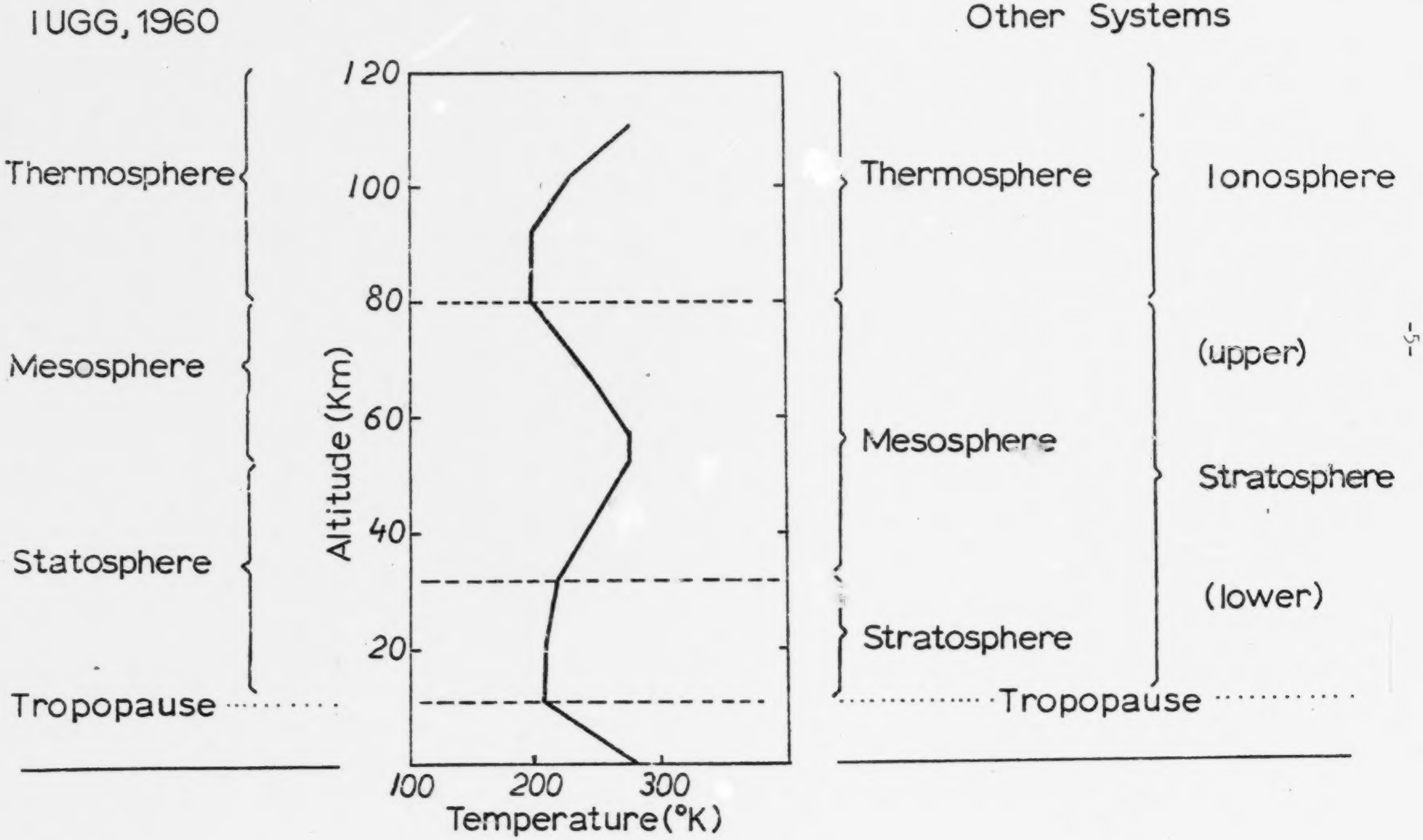


Figure 1

1000 km, and is not shown on the diagram. In the exosphere, particles can escape the earth's gravitational pull; therefore, this region marks the zone of transition between the earth's atmosphere and interplanetary space.

Scientists other than meteorologists and atmospheric scientists are interested in specific atmospheric processes. These people have developed systems of nomenclature used for various parts of the atmosphere, according to their particular interest. These alternative systems are included in Figure 1. It is hoped that this inclusion will prevent any misunderstanding in terminology.

C. Thermal Energy and Its Effects

Energy is commonly defined as the capacity to do work. It may take a number of forms: heat, mechanical, electrical, and chemical. The main source of the energy for our earth is the sun, and an important function of the energy from the sun is the heating of the earth's surface and our atmosphere.

Some points are to be noted in considering atmospheric dynamics:

1. An energy balance has existed over a few hundred years between the sun and the earth/atmosphere system (the Global Heat Balance is summarized in Figure 2). The incoming solar radiant energy (insolation) is taken to be equal to 100 units, or 100%. The absorption by ozone in the stratosphere is not considered in this diagram. Fifteen per cent of the insolation is absorbed by carbon dioxide, oxygen, ozone, water vapor, clouds, and dust in the troposphere. Forty-three percent of the energy reaches the earth's surface, both directly, and by radiation, which scatters from the troposphere. The remaining 42% of the energy,

GLOBAL HEAT BUDGET

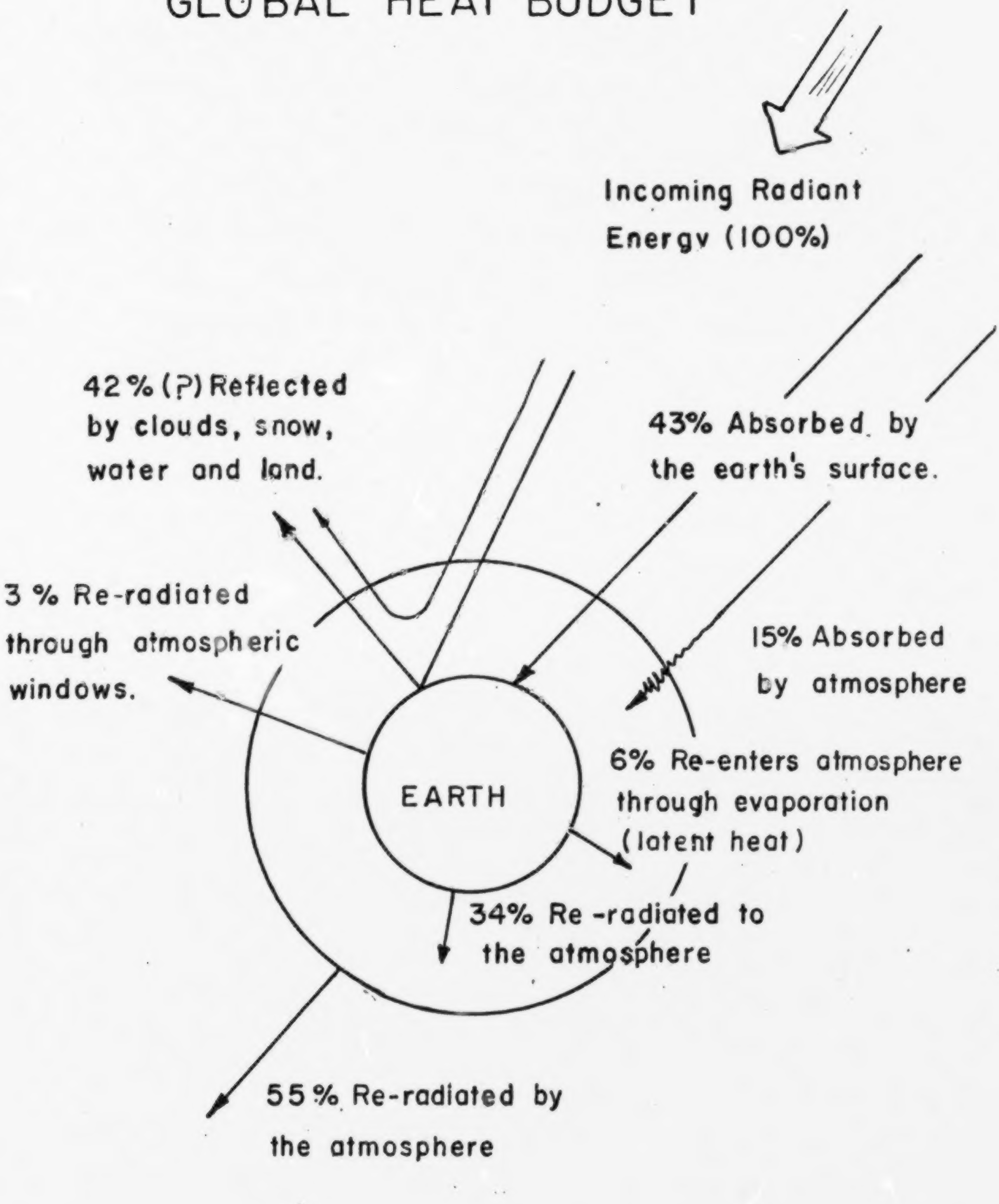

Incoming Radiant Energy (100%)
42% (?) Reflected by clouds, snow, water and land.
43% Absorbed by the earth's surface.
3 % Re-radiated through atmospheric windows.
15% Absorbed by atmosphere
6% Re-enters atmosphere through evaporation (latent heat)
EARTH
34% Re-radiated to the atmosphere
55% Re-radiated by the atmosphere

Figure 2

which is reflected back to space from the earth's surface (snow, water, land, clouds, and air molecular scattering), is known as the earth's albedo.

The incoming solar radiant energy is predominantly in the short wavelength region of the electromagnetic radiation spectrum. The outgoing radiation from the earth's surface and the troposphere reaches its height in the longer wavelength region of the electromagnetic radiation spectrum, known as the infrared region. Three percent of the outgoing radiation from the earth's surface leaves the atmosphere directly, and goes back to space. The majority of the energy that leaves the earth's surface is absorbed by carbon dioxide, water vapor, and cloud droplets in the troposphere; this energy is then radiated outward to space and backward to the earth's surface, thus further warming it. This phenomenon is known as the "Greenhouse Effect."

Some of the energy that leaves the earth's surface does so in the form of latent energy when liquid water is converted to the vapor phase. To achieve a balance for the atmosphere, we assume this evaporative process, along with conduction, to be 6% of the total heat loss.

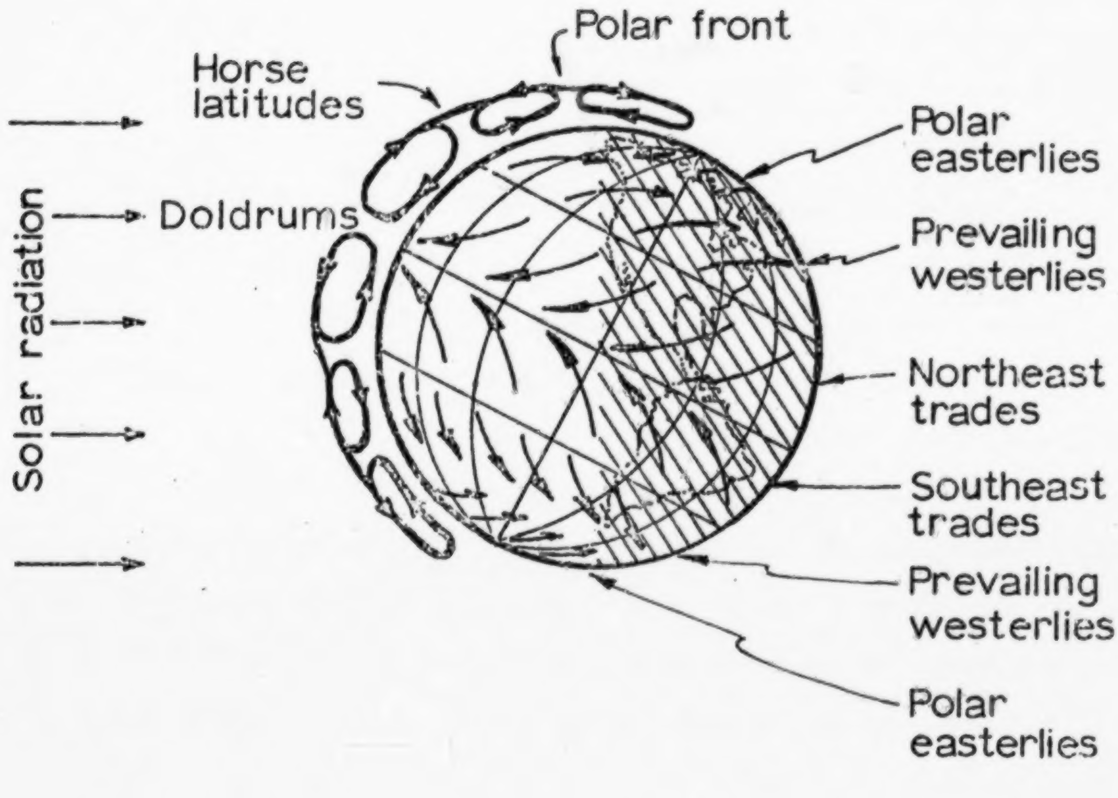
2. The uneven distribution of energy on the earth's surface, and the rotation of the earth about its axis, produce the large-scale, horizontal movement of air, called winds. Different substances absorb insolation at different rates. These different absorption rates, plus further differences in thermal conduction and mobility (e.g. gases vs. solids), result in uneven heating of the earth's surface. These combined processes produce three cells in the meridional plane (see Figure 3).

The cells closest to the equatorial and polar regions are called Hadley, or direct circulations. As the atmosphere closest to the earth's surface is warmed, it becomes buoyant and rises. The resulting circulations are energy-producing. The middle cell, in either hemisphere, is called a Ferrell, or indirect cell. In essence, this cell raises cool, dense air, and forces warm, light air downward. The end result of this process is the conversion of the energy generated by the Hadley cells into potential energy. The cells, then, are part of a simple thermal engine that moves energy from one location to another at a different latitude, helping to establish the heat balance of the earth/atmosphere system in the process.

The sinking air at the Horse Latitudes (30 degrees) is warmed by compression, and is quite dry (i.e. of low relative humidity). There is limited chance of precipitation, and, in fact, tremendous evaporation occurs at this latitude around the earth. The major deserts of the world are found near this region in both hemispheres.

The sinking process, because it is persistent, leads to two semi-permanent features in the Northern Hemisphere--the Bermuda and the Pacific high pressure regions. The Aleutian and Icelandic lows associated with the region denoted by the area marked "polar front," result from the same persistent air movement, except that this region represents air that is rising and cooling.

Along a band between two different latitudes, the uneven heating of the earth's surface produces both high and low pressure regions. As the air near the earth's surface flows from the high pressure region toward the low pressure region, it is deflected to the right (of an observer looking along the direction of flow) in the Northern hemisphere. This apparent deflection is attributed to the earth's rotation about its axis and is the


Polar front
Horse latitudes
Solar radiation
Doldrums
Polar easterlies
Prevailing westerlies
Northeast trades
Southeast trades
Prevailing westerlies
Polar easterlies

GLOBAL WIND PATTERNS

Figure 3

Coriolis deflection. The most important results of this deflection are the major wind systems, as labeled in Figure 3.

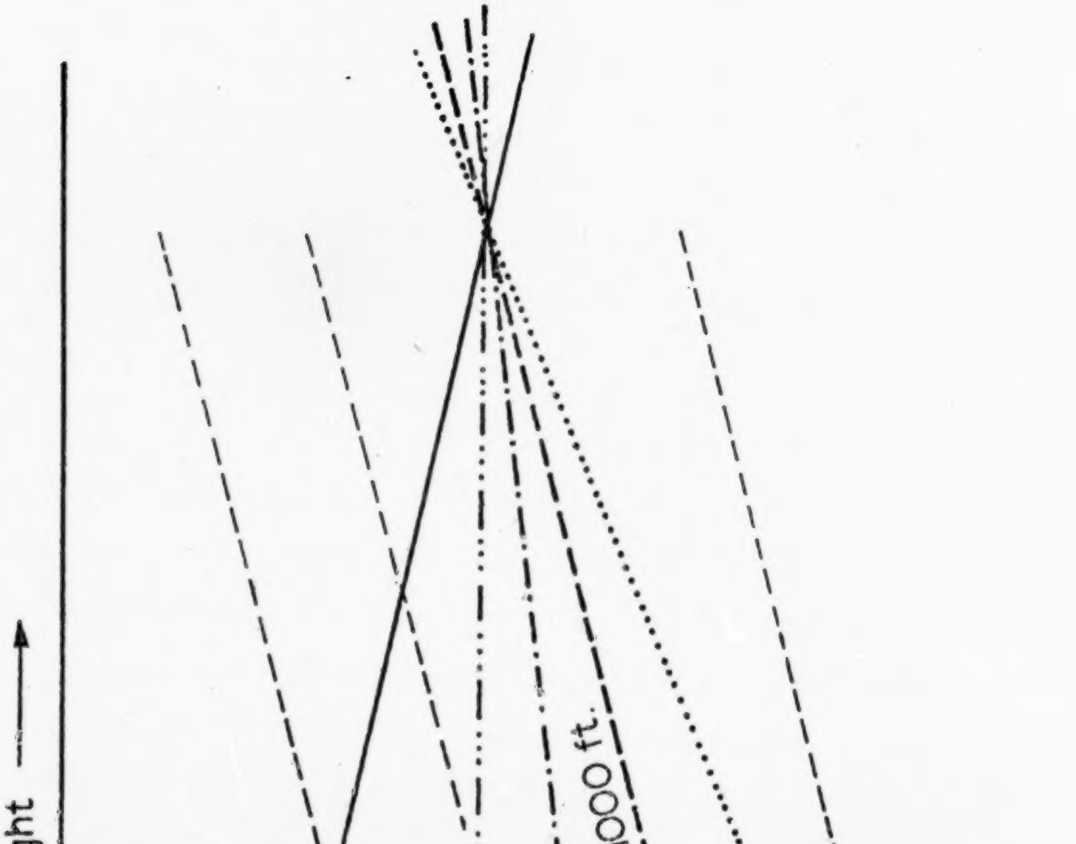
Winds are always named for the direction from which they blow. Furthermore, a west wind is one that is moving west-east faster than the earth is rotating in this direction, and an east wind is one that is moving west-east slower than the earth is rotating in the west-east direction.

D. Physical processes

There are physical processes in the atmosphere which may have an effect, whether detrimental or beneficial, on man. It is necessary to understand these processes in order that we may understand and influence our atmosphere. Control of the following processes is not within our present capabilities; however, we may, by our actions, inadvertently influence their balance, or produce an effect which is detrimental to our environment.

1. Lapse rates

   a. Vertical movement of air causes it to cool at a specific rate, depending upon its moisture content. When the air rises, it expands, because the pressure aloft is decreasing. This expansion requires work to be done at the expense of the internal energy of the volume of air. This lowers its temperature at the rate of 5.4 degrees F/1000 feet, or 10 degrees Celsius/km (see Figure 4). This specific rate is known as the dry adiabatic lapse rate, since no energy is exchanged between the ambient air and the rising parcel. When the air becomes saturated and water vapor begins to condense, the latent heat of vaporization causes the parcel


Height
Inversion
Isothermal
Weak lapse
Dry adiabatic 5.4 F°/1000 ft.
Strong lapse
Temperature

TEMPERATURE STRUCTURE WITH HEIGHT

Figure 4

to cool at a rate which is less than the dry adiabatic rate. This is termed the moist adiabatic rate.

b. The troposphere has, at any one time, a definite rate of temperature change in the vertical, which may suppress or enhance vertical air movement. The existing temperature decrease with height will vary with local atmospheric conditions (Figure 4). When the ambient air is isothermal, a rising parcel will first be buoyant and then become denser than the surrounding atmosphere. Where the two lapse rates cross, vertical motion is suppressed.

An inversion exists when the temperature increases with elevation. The parcel will again, for a short time, be buoyant, but the vertical ascent is rapidly suppressed beyond the crossing of the two lapse rates. The weak or the strong lapse will produce vertical motion that is enhanced. If the atmosphere should be "dry adiabatic," then the parcel will continue to rise at a constant rate.

Vertical motion of air is one of the major methods by which air pollutants are dispersed from their sources. Ejected into the upper atmosphere, the pollutants are readily moved horizontally by the strong winds aloft in the mid-latitudes. Any suppression of vertical motion leads to a concentration of pollutants locally, especially if there are light horizontal winds near the surface of the earth.

c. Suppression of vertical motion and the consequent concentration of pollutants can be produced by the advection of a warm air mass aloft, or by a radiation, subsidence, or frontal inversion.

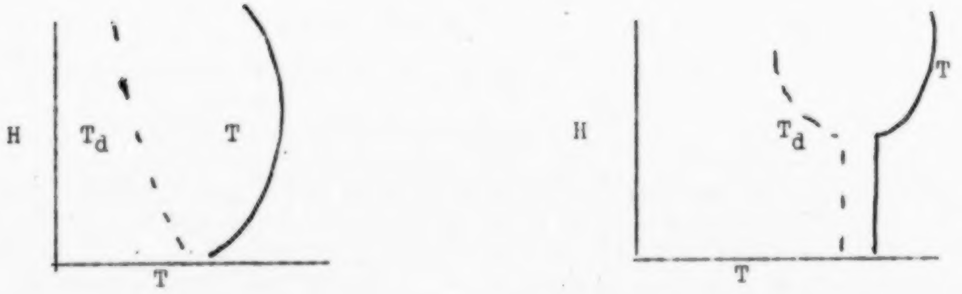
When meteorological conditions are appropriate, a large mass of warm air aloft may move over a locality. This produces an inversion aloft and effectively places a lid on any vertical convection from the earth's surface upward. If this situation persists long enough, serious local concentrations of pollutants may accumulate.

In Figure 5, diagrams A and B refer to subsidence inversions produced by high pressure regions. The curve T_d in these cases represents very dry air. The air descends and is heated by compression in a high pressure region. The inversion becomes particularly acute when the high pressure region stagnates for 4 or more days. Along the eastern seaboard, there is a maximum frequency of stagnation in October, and a secondary maximum frequency in June. A radiation inversion (Figure 5-C) occurs most frequently during winter nights, when clear, calm conditions prevail. The earth's surface is always radiating energy in the infrared region, resulting in cooling of both the earth's surface and the atmosphere in contact with that surface. In this type of inversion, the moisture content, T_d, is higher than in the case of a subsidence inversion. Usually this inversion produces maximum concentration of atmospheric pollutants in the early morning hours. Vertical motion produced by insolation eliminates the radiation inversion by late morning or early afternoon.

Figure 5

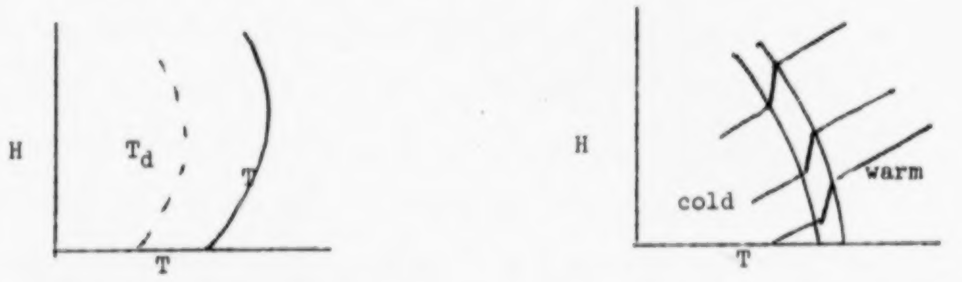
Inversion Temperature Structure

and Moisture Content


H
T_d
T
T
H
T_d
T
T

(A) Subsidence Inversion

(B) Subsidence Inversion


H
T_d
T
T
H
cold
warm
T

(C) Radiation Inversion

(D) Cold Frontal Inversion

Diagram D represents the temperature inversion structure that exists with a cold frontal system. However, frontal trapping can occur with either cold or warm fronts. The movement of the frontal system is important in determining the pollutant levels that can occur. The slower the frontal system moves, the higher the concentration of pollutants; for this reason, slower moving warm fronts are associated with large-scale trapping. Surface winds ahead of the warm front will usually be less intense than than those behind a cold front. In many instances, precipitation is associated with frontal activity; this precipitation will further reduce the concentration of pollutants because of its cleansing properties.

2. Cleansing processes

   a. The troposphere can cleanse itself by the natural mechanisms of impaction, precipitation and sedimentation. These mechanisms are responsible for removing particles from the atmosphere. An investigation of Figure 6 shows that at radii greater than about 10^{-4} cm. (1 micron), we find 99% of the particulate mass accounted for in the atmosphere. Very few particles are involved compared to the particles less than 10^{-4} cm. in radius, which account for 99% of the total number of particles found in the atmosphere.

      Particles larger than 0.1 - 1 micron in radius have high sedimentary rates. They settle out of the atmosphere within a short distance of their source because of the weight of the particles involved. Ten to forty percent of the particulate matter in the atmosphere is removed by sedimentation.

The impaction of airborne particulates with different structures is also an effective means of removal. Most darkening and discoloration of buildings occurs because of this process. If particulates adhere to each other upon impaction, the process is called coagulation. This results in increased mass and leads to sedimentation of the original particulates.

The majority of particulates are removed by some form of precipitation. The Aitken nuclei (Figure 6) are presumed to be produced as combustion by-products from automobiles, and are effective hygroscopic nuclei which initiate droplet formation. Other hygroscopic nuclei are salt particles from sea spray, and smoke. These particles absorb moisture and produce droplets ranging from 10-100 microns, which are found in clouds. The droplets grow upon collision when convective motions are produced within the clouds. The resulting droplet growth produces small to large rain drops in the range of 1,000 to 5,000 microns. The raindrops capture more particles by collision as they descend. This is a temporary cleansing effect, since the rain does not last forever; but the sources of particulate pollution usually continuously emit particle pollutants into the atmosphere.

Another mechanism responsible for rapid growth of liquid droplets involves ice crystals. Water vapor con-

AIRBORNE PARTICLE TERMINOLOGY

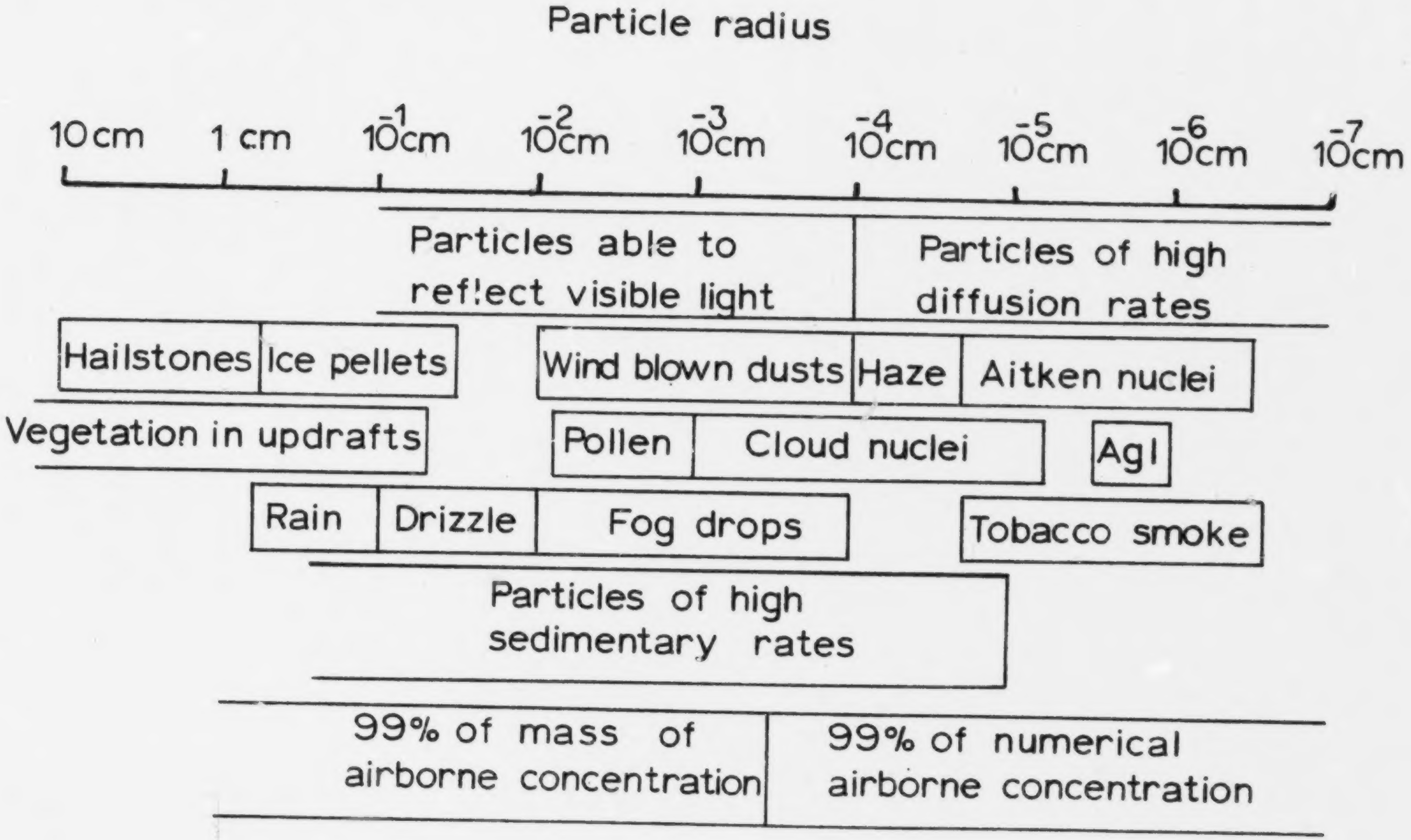

Particle radius
10 cm
1 cm
10^{-1}cm
10^{-2}cm
10^{-3}cm
10^{-4}cm
10^{-5}cm
10^{-6}cm
10^{-7}cm
Particles able to reflect visible light
Particles of high diffusion rates
Hailstones
Ice pellets
Wind blown dusts
Haze
Aitken nuclei
Vegetation in updrafts
Pollen
Cloud nuclei
AgI
Rain
Drizzle
Fog drops
Tobacco smoke
Particles of high sedimentary rates
99% of mass of airborne concentration
99% of numerical airborne concentration

FIGURE 6

denses rapidly on ice crystals, and a sizable droplet results in a very short time. Freezing nuclei are about 1/1000 the number of hygroscopic nuclei per liter. Sources of freezing nuclei are volcanoes, meteoric dust, lead iodide, and silver iodide. Nuclei from the latter two sources may lead to weather modifications, producing either precipitation or drought. The end result depends upon the amount of freezing nuclei and water vapor present.

An important idea must be put forth here. Particles are necessary for the production of precipitation. With an absolutely clean atmosphere it is highly probable that there would be no precipitation at all. Paradoxical as this may seem, particles, or major atmospheric pollutants, are necessary for precipitation to occur; the precipitation then removes the particles which had initially caused its onset.

b. The atmosphere can effectively localize gases and particles without removal by the formation of clouds. At any instant in the troposphere, there are more liquid water droplets in clouds than in rainwater. As convective currents and entrainment occur at the edges of the cloud, the cloud droplets can act as a filtering system for the atmosphere. The droplets capture particles by impaction, and if the droplet evaporates, a residual, larger particle is left, which can then be removed by sedimentation. The particles themselves adsorb various gaseous pollutants on their surfaces; this process involves complex chemical and physical processes. Cloud droplets can absorb gaseous pollutants which go into solution, forming weak acids.

Thus cloud droplets may be part of a series of chemical reactions which convert gases into aerosols.

TABLE 3

SELECTED EQUATIONS FOR THE
CONVERSION OF A GAS INTO AN AEROSOL

(1) $M + O + SO_2 \rightarrow M + SO_3 + H_2O \rightarrow M + H_2SO_4$

(2) $H_2O + 2NO_2 \rightarrow HNO_2 + HNO_3$

(3) $H_2O + CO_2 \rightarrow H_2CO_3$

c. The stratosphere may be cleansed by the vertical transport of air associated with a frontal system or intense thunderstorm activity. The tropopause, which is the boundary layer between the troposphere and the stratosphere, was originally thought to prevent any exchange of air between the two lower regions of the atmosphere. As more atmospheric data was gathered and analysed, it was found that breaks, associated with frontal activity, occurred in the tropopause, and therefore it is possible for exchanges to occur in the frontal region between the stratosphere and the troposphere.

Radioactive material in the stratosphere may readily descend upon the earth's surface in dangerous amounts and concentrate in localized areas. The most recent investigation of cumulonimbus, or thunderstorm, clouds indicates that they may extend well into the stratosphere. Within these clouds, violent up and down drafts occur, which can transport the radioactive material to the earth. Scientists are searching for correlations between thunderstorm activity and increased thyroid abnormalities, which may result from Iodine-131 radiation. Laboratory tests have been performed on children living in the Utah-Nevada area.

3. Photochemical processes

   a. Another series of chemical reactions which may occur in the atmosphere are the photochemical processes. The term photochemical is used since incoming light energy, primarily in the ultraviolet region, drives the chemical reaction.

   Without a certain minimum intensity of radiation, the reactions are impossible. Moreover, since new products are formed by these reactions, there is no definitive list of pollutants found in any area. A prime example of this is a suggested list of seventeen reactions which produce peroxyacyl nitrate (PAN). The production of PAN, which is one of the major pollutants of the photochemical smog prevailing in Los Angeles is a serious problem, since the molecule is a severe irritant.

   At the other end of the scale exists a series of beneficial chemical reactions which protect humans from the harmful effects of certain wavelengths of ultraviolet radiation. They produce esthetically pleasing "blue hazes," typical of the Virginia Blue Ridge Mountains, by converting terpenes into aerosols.

   The equilibrium reactions mentioned in connection with the stratosphere are shown in Table 4, below.

TABLE 4

SELECTED PHOTOCHEMICAL REACTIONS

	$O_2 + O + M \rightarrow O_3 + M$
Less than 11,000Å	$O_3 + hf \rightarrow O_2 + O$
Less than 2,423Å	$O_2 + hf \rightarrow 2O$
	$M + O_3 + O \rightarrow 2O_2 + M$

In this series of reactions, the rates of production of ozone, diatomic oxygen, and monatomic oxygen are such that an equilibrium exists among the three. Without the photochemical production of ozone, the absorption of harmful ultraviolet radiation might not occur. Of course, ozone found at the earth's surface is responsible for the corrosion of metals, the production of nitrogen dioxide, and the deterioration of rubber and leather goods.

4. Electrical phenomena

   a. The greatest danger of pollution in nature is from thunderstorms with their attendant lightening discharge between the earth's surface and the atmosphere. The heating effect of the stroke may produce fairly high concentrations of ozone. Usually this is not a serious problem because the intense vertical motion associated with the storm dilutes the concentration of ozone rapidly. A greater source of danger is the production of forest fires during a dry spell. The resulting smoke, or particulates, may be traced as a haze layer across the entire continental United States when a severe fire persists for a long period of time.

Polluted air is a poor conductor of electricity, since gases may capture charged particles and can therefore affect earth-atmosphere charge distribution. This may be no cause for concern; however, there is a possibility that precipitation may be influenced and even initiated in some way by electrical charge distribution in the atmosphere. A severe local pollution problem may affect precipitation patterns in certain localities.

An interesting effect of electricity is that of an extremely high concentration of negatively charged particles on one's health. The number of particles involved is in excess of any number found in the atmosphere; yet, for the treatment of certain disorders, there have been positive results when patients have undergone charged particle treatments.[1]

E. Local topographic effects

1. Industrialization in valleys, particularly near bodies of water, leads to pollution problems, since cold drainage winds establish inversions during the night. This is known as the "valley effect" (see figure 7). In the evening the hillside cools more rapidly than the valley for two reasons:

   a. The ventilation in a valley is less turbulent than that of the surrounding mountainside, and the valley tends to retain its heat.
   b. The mountainside, being higher than the hillside and continually radiating energy in the infrared, loses

---

[1] Landsberg, H.E., Weather and Health, p. 13.

energy more rapidly. The cooler drainage winds, because of their density, flow down the sides of the valley and fill the bottom of the valley with very cold air in the early morning. The valley now has warmer air aloft and colder air at, and just above, its bottom; therefore, an inversion exists. In the morning, as insolation is absorbed on the mountainside, a circulation is set up, which moves the pollutants trapped by the inversion up the mountainside, but because of the inversion lid, the pollutants are returned to the valley floor.

If an inversion occurs and fog exists in the valley, the concentration of pollutants can become quite severe before the fog is evaporated and the inversion disrupted. Spectacular photographs exist of a polluted fog pouring through a mountain gap as if over a waterfall.

2. The effect of hills or ridges on pollution depends upon the location of the source of pollution and on atmospheric stability. Under very stable conditions, air flows around a hill or ridge; when instability exists in the atmosphere, the air flows over a hill, mountain, or ridge. A source of pollution upwind from the orographic feature will strike the hill or ridge under unstable atmospheric conditions. Homes or structures on the hillside will receive the full brunt of the pollutants, while these same structures would not be affected by stable conditions.

When pollution sources are located on the lee side of the mountain, the descending air tends to move away from the mountain in a vertical wave pattern, termed roll clouds. In this instance, the pollutant can be brought down to the earth's surface at quite a distance

The Valley Effect

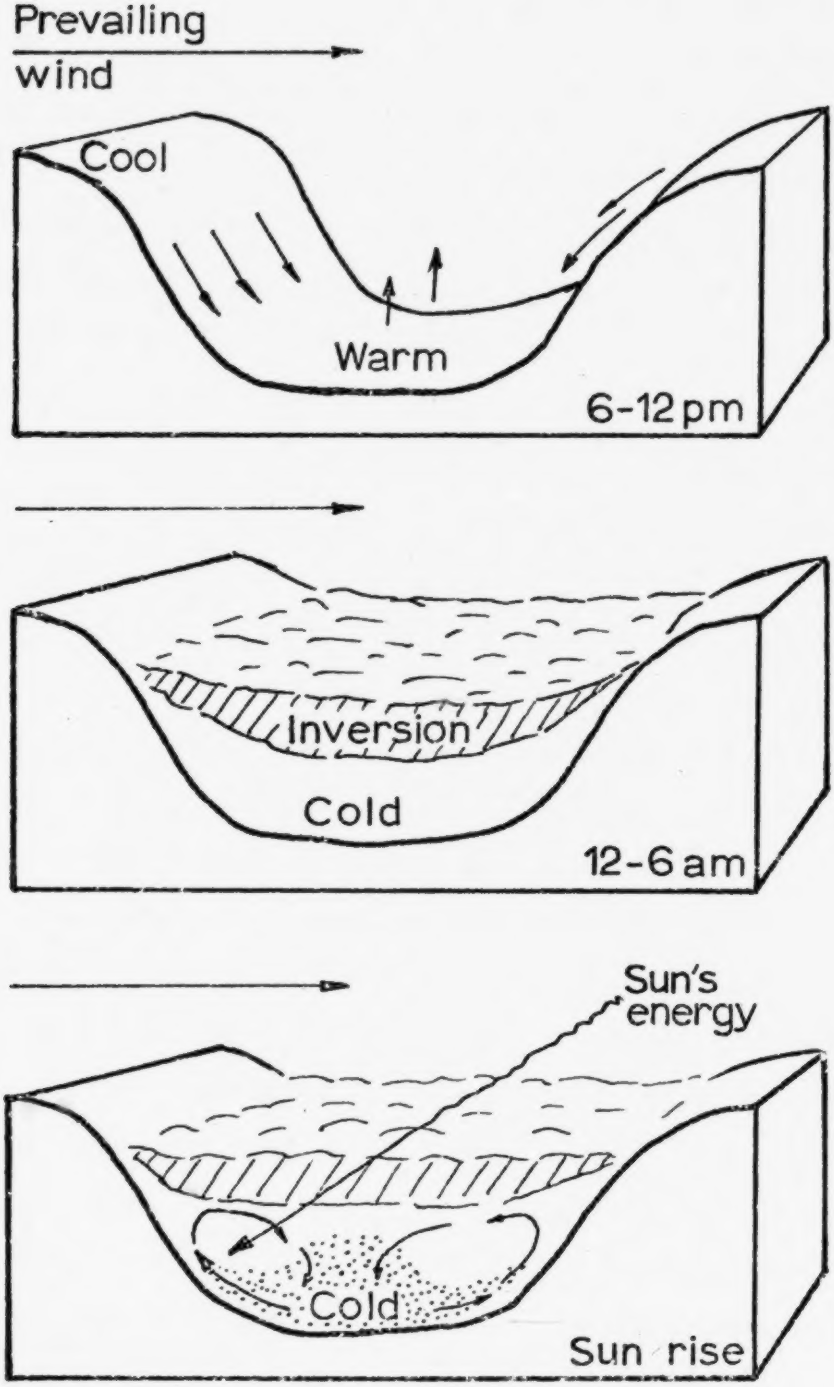

Prevailing
wind
Cool
Warm
6-12 pm
Inversion
Cold
12-6 am
Sun's
energy
Cold
Sun rise

Figure 7

from the source. There will also be turbulence in the lee of the source of pollution; such turbulence will bring large concentrations down to the surface within a fairly short distance of the source. Climatological studies of an area are necessary before local planning and zoning can be established, especially for large, persistent sources of pollutants.

3. Shoreline winds which are quite strong, may be modified by the land mass to produce a diurnal inversion or localized pollution downwind. The "sea-breeze" or "lake breeze" effect may extend from two to five miles inland on any given day. The inland penetration depends upon local terrain, large pressure systems masking the breeze effect, and the temperature difference between the land and water masses.

The flow of cool, moist onshore air, which is associated with the sea or lake breeze, is a welcome relief during a hot summer's day. However, the temperature structure of the air moving onshore is very important (see Figure 8). Cool air at the surface of the water and warm air aloft create an inversion which moves onshore. If a power generation plant, a fertilizer plant, or any other pollution source is located onshore, the emissions from the source are trapped under the inversion. This process is depicted at the bottom of Figure 8. As the breeze moves inland, its lower layers are heated; a strong lapse rate is produced in the lower layers of the breeze by the temperature modification of the air in contact with the surface of the earth. The strong lapse rate produces vertical up and down drafts that cause a plume to loop; therefore, the pollution is brought down to the surface of the earth at considerable distances from its source.

4. A large body of water and attendant concentration of industry may modify the climate of a locality downwind. In considering the above statement, one assumes that the industry center does not control its emissions, and that large masses of condensation, or ice

nuclei, are injected into the atmosphere. As these nuclei are carried along over a large body of water downwind, a great amount of moisture is added to the atmosphere. Any orographic effect or thermal effect from another city at the opposite edge of the body of water will produce vertical motion. These mechanisms usually aid or produce what is known as the "lake effect" weather, found on the eastern sides of the Great Lakes. It is possible that the combination of the industry near Gary, Indiana, together with moisture from Lake Michigan produce abnormally large amounts of precipitation downwind, for example, in La Porte, Indiana.

F. The effects of cities

The climatological comparison of an urban area with a rural area is summarized in Table 5.

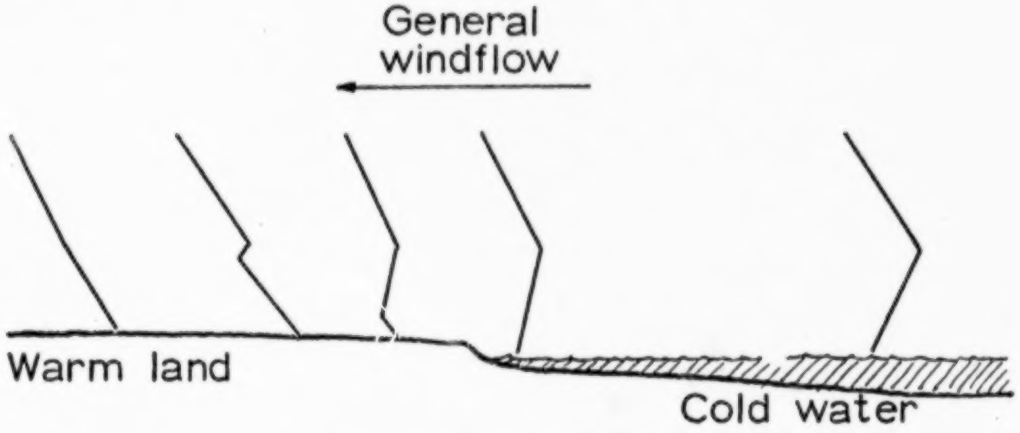
Climatic Changes in an Urban Community

Climatic factor	% difference, urban
cloudiness	5-10 +
winter fog	100 +
summer fog	30 +
precipitation	5-10 +
solar radiation, ground level	~ 30 -

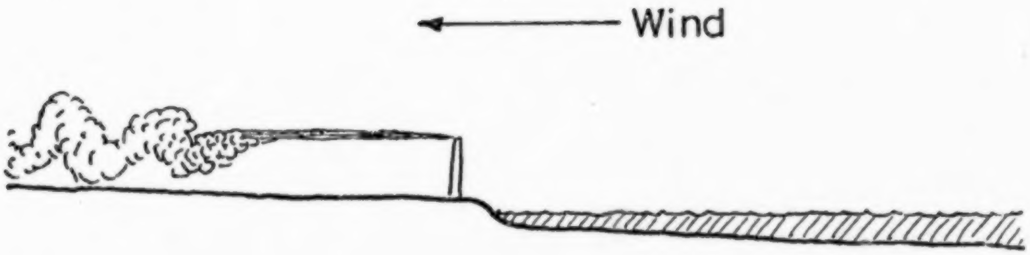
TABLE 5

Most of the effects summarized in Table 5 can be attributed to the Heat Island Effect (see Figure 9). The urban area, being slower to cool than the surrounding rural area, is a warm source surrounded by a cooler region. This creates a slow, rising motion of the air over the city, a rising air mass which cools and descends near the edges of the urban area. It is this cool, particle-laden [illegible]

VERTICAL TEMPERATURE STRUCTURE


General windflow
Warm land
Cold water

Late spring, afternoon



Effect upon plume characteristics

Figure 8

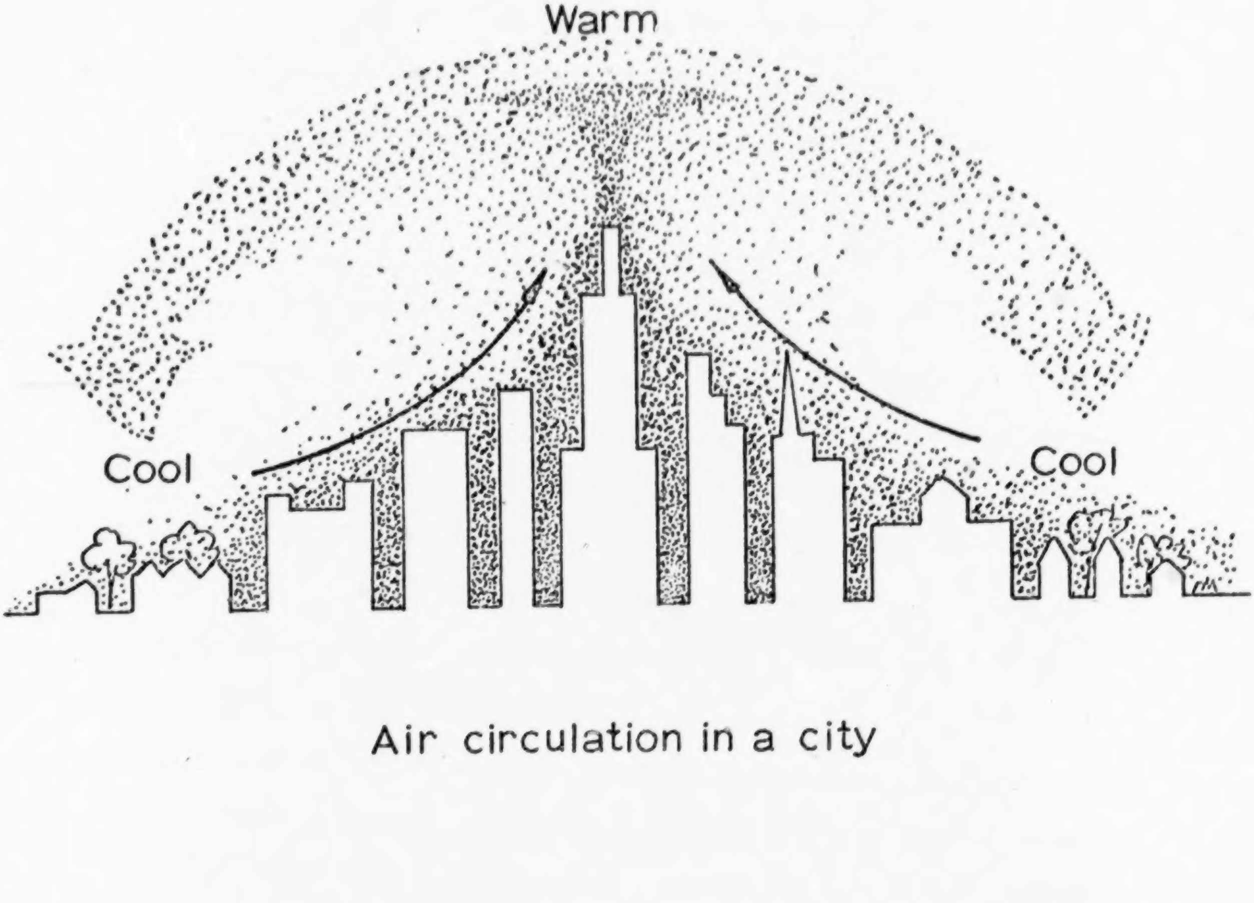
instead of cool, clear, rural air, that is brought into the urban area (see Table 6). This return of polluted air is one part of the reason for likening a modern city to a volcano in a desert which continuously belches forth noxious effluents into desolate streets.

Even though the precipitation is greater over a city than over a rural area, the city has both lower relative and absolute humidity than the surrounding air. This phenomenon is the result of two factors. One is the greater runoff of precipitation from the paved surfaces of the urban area. Secondly, humidity is temperature-dependent. The elevated temperatures resulting from radiant heat loss to the ambient air from urban activities reduces the relative humidity and the absolute moisture content of the urban air.

Urban increased cloudiness has many important ramifications. The increased cloud cover, along with the great numbers of small particulates, decreases the ultraviolet radiation received at the surface of the city. This increases the possibility of bacterial or virus infections, since ultraviolet light destroys these organisms. Conversely, it does decrease the potential for the formation of photochemical smog. Moreover, clouds interfere with the development of convective processes which could rid the urban area of pollutants. Firstly, clouds lead to a faster increase in particle size and to attendant sedimentation; a decrease in particulates is expected with increased cloudiness. Secondly, the decrease in particulates increases concentrations of gases, since there is a decrease in the surface area of adsorbent material.

One of the major problems with which a city must concern itself is planning for growth and industrial zoning. Within or at the edges of every major city will be found the stacks used for disposing of wastes and gases associated with industry. When certain atmospheric conditions

THE HEAT ISLAND EFFECT*


Warm
Cool
Cool

Air circulation in a city

---

* After Pollution Primer, p. 17.

Figure 9

TABLE 6

AVERAGE DUST CONCENTRATIONS FOR UNITED STATES COMMUNITIES

Community	Dust load g/m^3
rural	40
suburban	70
city less than 0.7 million people	110
city 0.7 - 1.0 million people	150
city larger than 1 million people	200

prevail, the height and location of the stack may help with the dispersing of pollutants (see Figure 10).

The superadiabatic conditions shown at the top of Figure 10 occur only with light winds and strong solar heating. The pollutants will reach the surface at points separated from each other and at quite a distance from their source. Cloudiness or high winds will prevent such a situation from occurring.

When a stack extends above a surface inversion and into a superadiabatic region, gases cannot reach the surface; however, particles with appreciable settling velocities will drop through the inversion. The effluent of a stack located in an upper air inversion is trapped and spreads horizontally. As solar heating of the earth's surface increases, during clear skies and light winds, conditions typical of a summer day, the lower layers of air become superadiabatic. This super adiabatic lapse rate occurs through an increasingly deeper layer until the inversion is reached. The thermal turbulence associated with the superadiabatic conditions in the lower layers of the atmosphere carries high concentrations of pollutants to the surface along the entire length of the plume.

Trapping is produced when a stack is below a frontal or subsidence inversion. Nearly all of the pollutants are held below the inversion and can produce severe conditions some distance from the source.

G. Interacting atmospheric subsystems

Although our spaceship earth constantly receives energy from outside sources, we have no similar extraterrestrial source of carbon, oxygen, nitrogen, potassium, and sulfur, and other essentials for life. These substances must continually be recycled throughout the ecosystem if we and the system are to persist. The present ecological balance can easily be displaced by upsetting one or more of the interconnecting links, resulting in a new unknown balance, possibly toxic to man.

Probably the most useful concepts for the student to have in mind in attempting to grasp the significance of cycles in the moderation of air pollution, is that all of the compounds which we classify as pollutants are produced in natural processes. He should also be aware that, in undisturbed conditions, an equilibrium is established between the production of the specific end product of a process, such as respiration, and the environment into which it is introduced. In other words, some part of the environment, at equilibrium, acts as a receptor for the end product of the reaction. This receptor is commonly termed a sink. If such sinks exist for the small amounts of materials in a "natural" reaction, they should also function in the removal of large, polluting amounts of the same materials. Identification of the equilibrium reactions and the involved sinks can be instructive in understanding the natural cleansing processes, and why these seem to have broken down in some instances.

1. The carbon cycle

The carbon cycle is an excellent starting point for examining

FOUR PLUME CLASSES

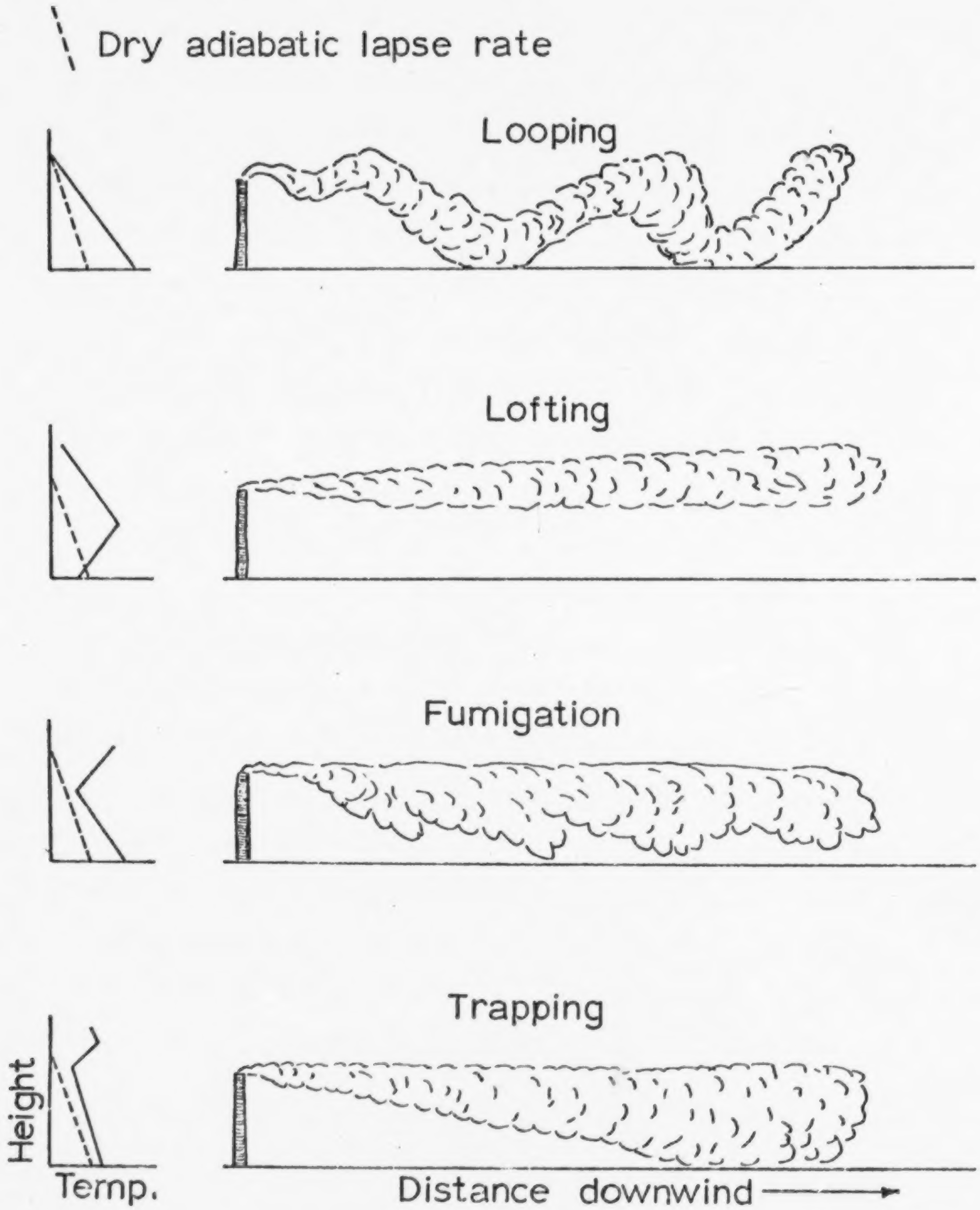

Dry adiabatic lapse rate
Looping
Lofting
Fumigation
Trapping
Height
Temp.
Distance downwind

Figure 10

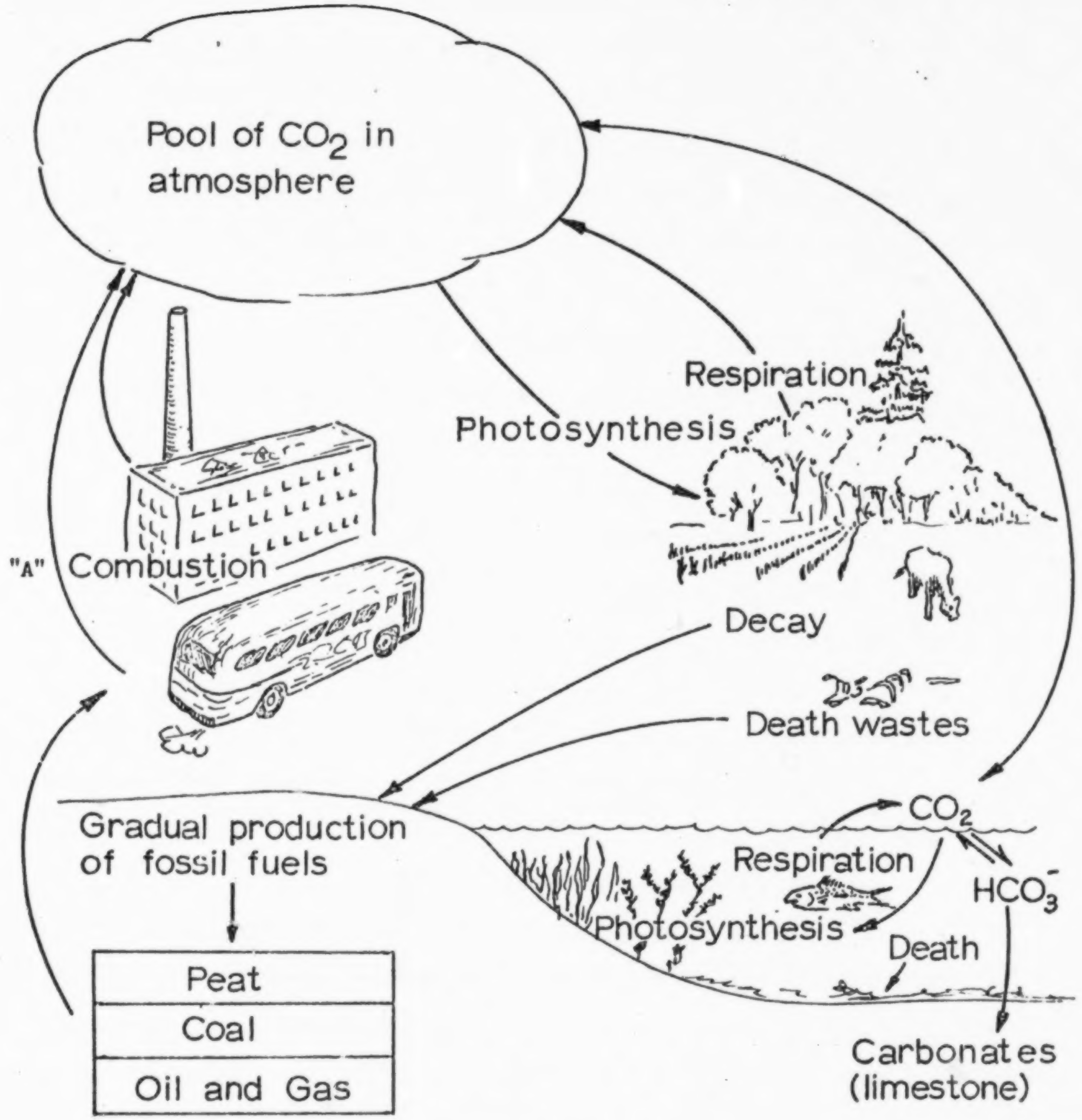
natural equilibria and the unbalancing forces which man has introduced by his societal activities (see figure 11 on page 35). The point of production of carbon monoxide provides a good entry point into the cycle (point A in the diagram). Carbon monoxide (CO) is the product of burning carbon-containing fuels (e.g. coal, gasolines, natural gas) in a limited supply of oxygen. An excess of 72 million tons of carbon monoxide is put into the air as a result of these incomplete combustion processes, approximately 66 million tons of which are produced by the internal combustion engine. Concentrations of these gases vary from 1 to 2 parts per million, to 400 parts per million on city streets during peak rush hours. A recent study made on the F.D.R. Drive in New York City showed a variation from a low of 8 p.p.m. at 4:00 A.M., to a high of 86 p.p.m. at 8:00 A.M. Compilation of CO levels over a period of years show no accumulation commensurate with these rates of production.

The question is, then, where is the sink and by what mechanism is the carbon monoxide exhausted? Carbon monoxide is relatively low in reactivity under the conditions of the lower atmosphere. Consequently, oxidation to carbon dioxide does not occur to the extent necessary to remove significant quantities of CO. Other mechanisms have been proposed, including the conversion of CO to hydrocarbons by bacterial action. Although no conclusive evidence exists, one process which occurs in the stratosphere seems to be most likely:

$$2CO + 2OH \rightarrow 2CO_2 + 2H \qquad \text{(Equation 1)}$$

This reaction will occur at the energy levels available and will account for the conversion of carbon monoxide to carbon dioxide.

Other sources of carbon dioxide include the burning of fossil fuels, respiration of living organisms, and bacterial decomposition of organic residues. Carbon dioxide, regardless of its source, has a


Pool of CO_2 in atmosphere
Respiration
Photosynthesis
"A"
Combustion
Decay
Death wastes
Gradual production of fossil fuels
Peat
Coal
Oil and Gas
CO_2
Respiration
HCO_3^-
Photosynthesis
Death
Carbonates (limestone)

CARBON CYCLE

Figure 11

residence time in the atmosphere of approximately ten years. Some of this is removed by green plants in the process of photosynthesis. At 320 parts per million it is typically the limiting factor in the photosynthetic process. Considerable quantities, especially those produced by respiration in root systems, are dissolved in soil water. This portion creates an acid condition (Equation 2) necessary for the solubility of minerals requisite to proper plant nutrition.

$$CO_2 + H_2O \longrightarrow H^+ + HCO_3^- \qquad \text{Equation 2}$$

Eventually, much of this carbon dioxide becomes part of insoluble deposits of calcium carbonates. The same process occurs in the formation of the shell or bone structures of animals.

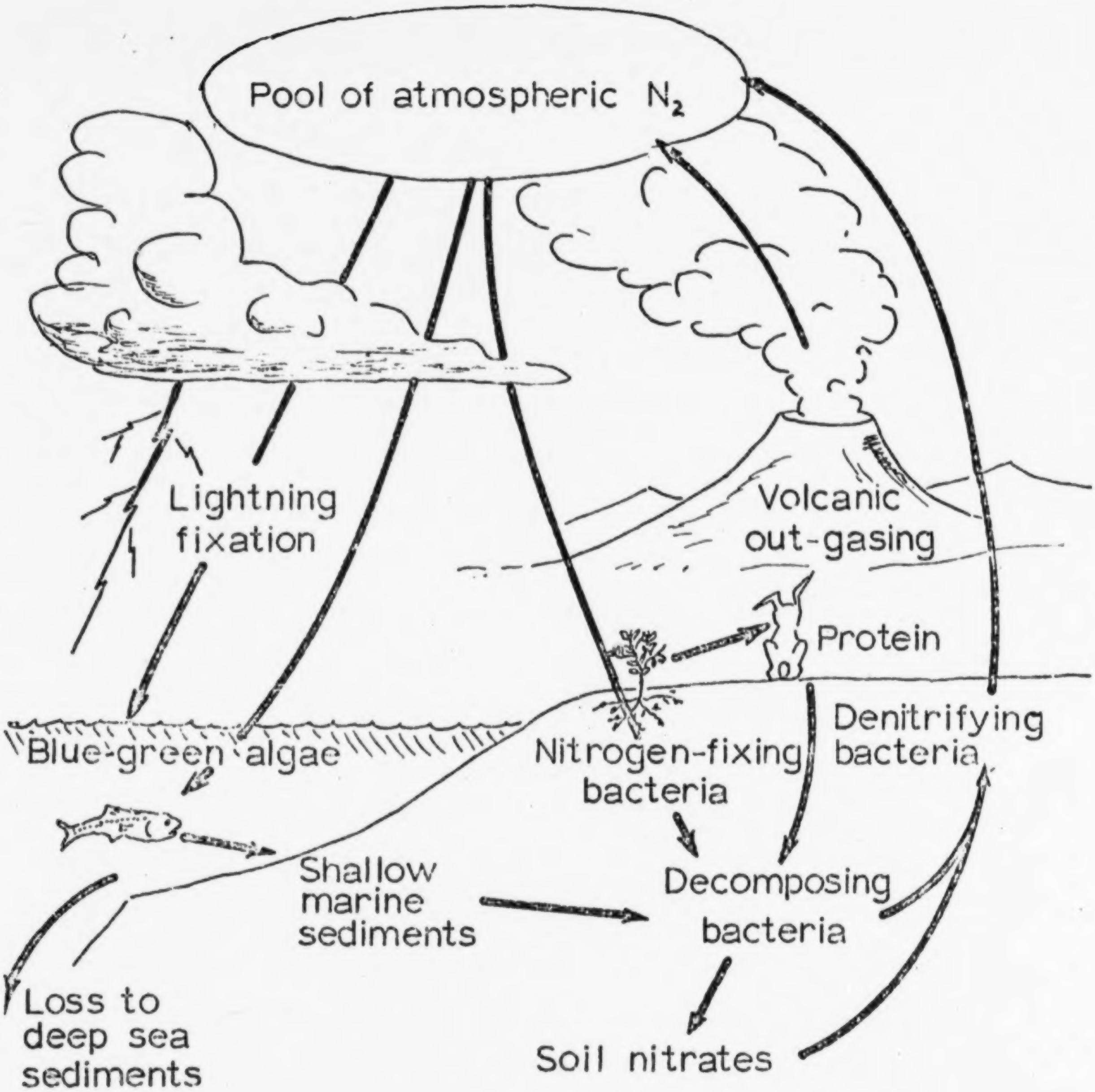
Probably the major sink for carbon dioxide is sea water, which contains sixty times the concentration of carbon dioxide found in the air. However, the problem rests in the slow rate of equilibrium change. The seas will continue to absorb some 100 billion tons of carbon dioxide per year, increasing only gradually with the increase in atmospheric concentration. Consequently, it is reasonable to expect a continuation of the trend which has increased atmospheric carbon from 312 parts per million during the decade 1960 through 1969.

2. The nitrogen cycle

Again, we can establish that those oxides of nitrogen, i.e. N_2O, NO, NO_2, which are produced by the high temperature oxidation of nitrogen (Equation 3) do occur under high energy conditions in nature.

$$N_2 + O_2 \xrightarrow{\text{high energy}} 2NO \qquad \text{Equation 3}$$

Atmospheric nitrogen is commonly fixed in a reaction with atmospheric oxygen in the presence of energy from lightening discharges. Approximately 4 million tons are fixed this way each year. The nitric oxide (NO) formed in this way oxidizes rapidly to nitrogen dioxide, or NO_2, a


Pool of atmospheric N_2
Lightning fixation
Volcanic out-gasing
Protein
Blue-green algae
Nitrogen-fixing bacteria
Denitrifying bacteria
Shallow marine sediments
Decomposing bacteria
Loss to deep sea sediments
Soil nitrates

NITROGEN CYCLE

Figure 12

poisonous, yellow-brown gas. This gas reacts with airborne alkalis

$$2NO + O_2 \xrightarrow{\hspace{2cm}} 2NO_2 \qquad \text{Equation 3a}$$

and is deposited as nitrate salts. Man has upset this equilibrium by the introduction of the internal combustion engine. At the high pressures and temperatures present in the combustion chamber, nitric oxides are formed at a rate of about 13 million tons per year. Particularly under inversion conditions, which restrict the distribution of effluents, nitric oxides tend to accumulate in hazardous quantities.

Nitrates formed from oxidizing atmospheric nitrogen are deposited in the soil, where they may move in one of three directions. That quantity which is absorbed by plant roots becomes incorporated into plant proteins and into the proteins of the animals which consume these plants (figure 12). Organic wastes decay in a series of steps from which different soil bacteria derive energy. Ultimately nitrates

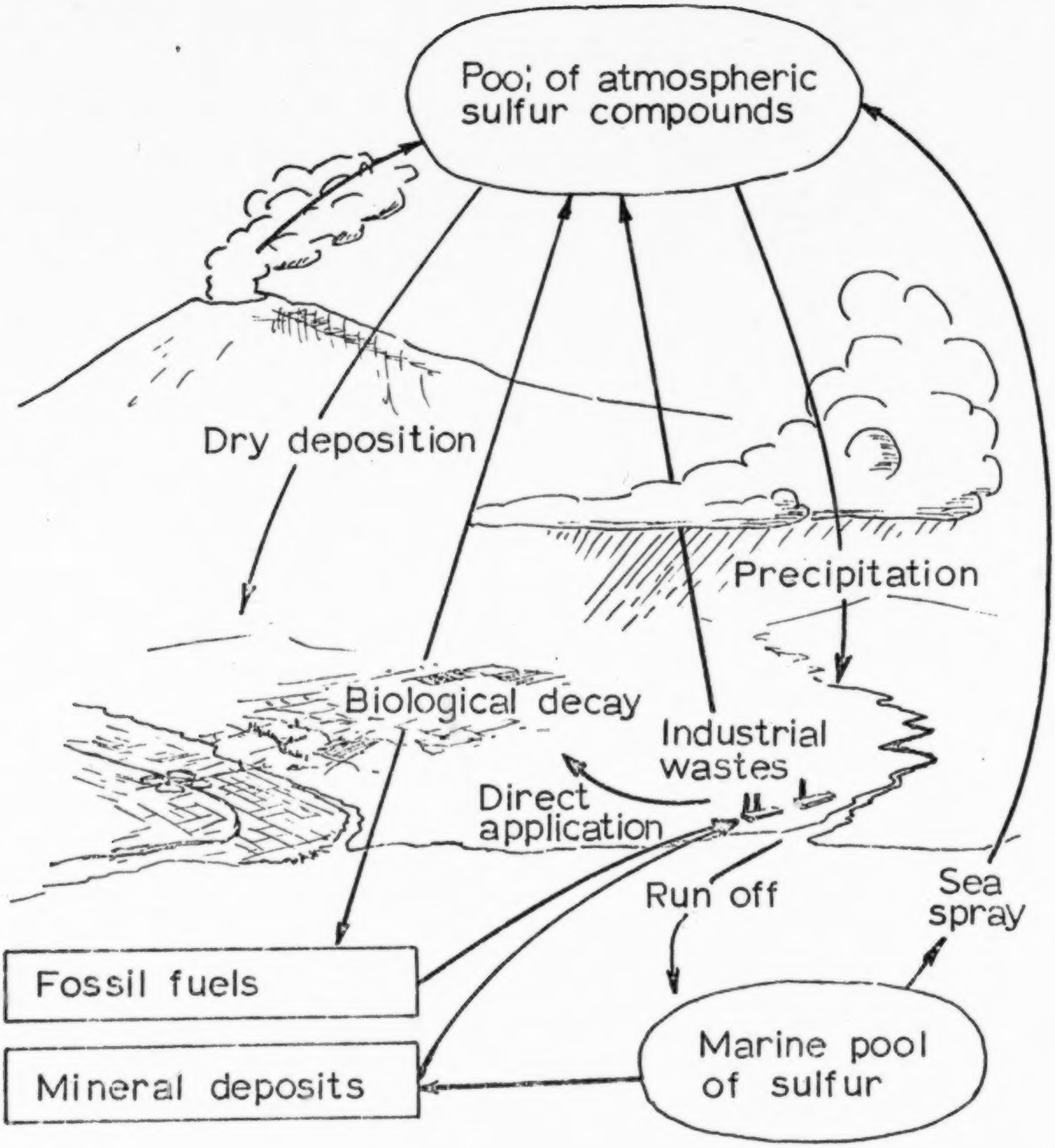
$$\begin{aligned} &\text{Organic nitrogen} \xrightarrow{\text{Bacillus pseudomonas}} NH_3 \\ &NH_3 \xrightarrow{\text{Nitrosomonas bacteria}} NO_2 \qquad (4) \\ &NO_2 \xrightarrow{\text{Nitrobacters}} NO_3 \end{aligned}$$

are formed. These may recycle, or, as may happen with any soil nitrates, they may be denitrified by bacterial action to molecular nitrogen, N_2. This molecular nitrogen will return to the atmosphere. As a third alternative, the highly soluble nitrate may leach out of the soil into bodies of water where it may contribute to the water pollution problem.

The natural nitrogen cycle has been further unbalanced by industrial fixations of nitrogen, which, at 80 million tons, constitutes over 1/3 of the total nitrogen fixed by all processes.

3. The Sulfur Cycle

Most sulfur in the air is the product of decay of organic matter (see Figure 13). This decay, under anaerobic conditions, produces approximately 68 million tons of sulfur in the form of hydrogen sulfide.


Pool of atmospheric sulfur compounds
Dry deposition
Precipitation
Biological decay
Industrial wastes
Direct application
Run off
Sea spray
Fossil fuels
Mineral deposits
Marine pool of sulfur

SULFUR CYCLE

Figure 13

Burning of fossil fuels will produce, as a by-product, 26 million tons of sulfur dioxide, SO_2. The hydrogen sulfide from biological decay will also oxidize in the atmosphere, producing water and sulfur dioxide.

$$2H_2S + 3O_2 \longrightarrow 2H_2O + 2SO_2 \qquad (5)$$

Normal residence time in the air for these oxides of sulfur is from five days to three weeks. This comparatively short duration of sulfur oxides implies a mechanism for their removal. Most typically, the mechanism is a photochemical process using ultraviolet light from the sun as a source of energy, and producing sulfur trioxides as a product (Equation 6)

$$SO_2 + O \xrightarrow{NO_2,\ UV} SO_3 \qquad (6)$$

Sulfur trioxide reacts readily with water to form sulfuric acid which can then be removed in the form of precipitation. This reaction (Equation 7) requires the presence of a particle, M, as a reaction site, and produces a fine mist, or aerosol, of sulfuric acid.

$$SO_3 + H_2O + M \longrightarrow H_2SO_4 \text{ (aerosol)} \qquad (7)$$

Alternatively, sulfur dioxide will oxidize, in an atmosphere containing ammonia, producing SO_3. The ammonia will react with the resultant sulfuric acid to form ammonium sulfate, which will in turn precipitate.

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4 \qquad (8)$$

A major problem inherent in overloading the sulfur cycle with oxides of sulfur is the tendency of sulfuric acid and its acid salts to accumulate in excess in the natural sinks (i.e., lakes, streams, and oceans). Rain water in the pH range of 4.0 - 4.5 has been recorded downwind of industrial areas. Some European lakes have shown drops from pH 7.3 to 6.8. If this trend were to continue to the 5.0 - 6.0 range, many species, such as salmon, could not survive.

4. The Water Cycle

The total world's water supply is estimated to be in the order

WATER CYCLE

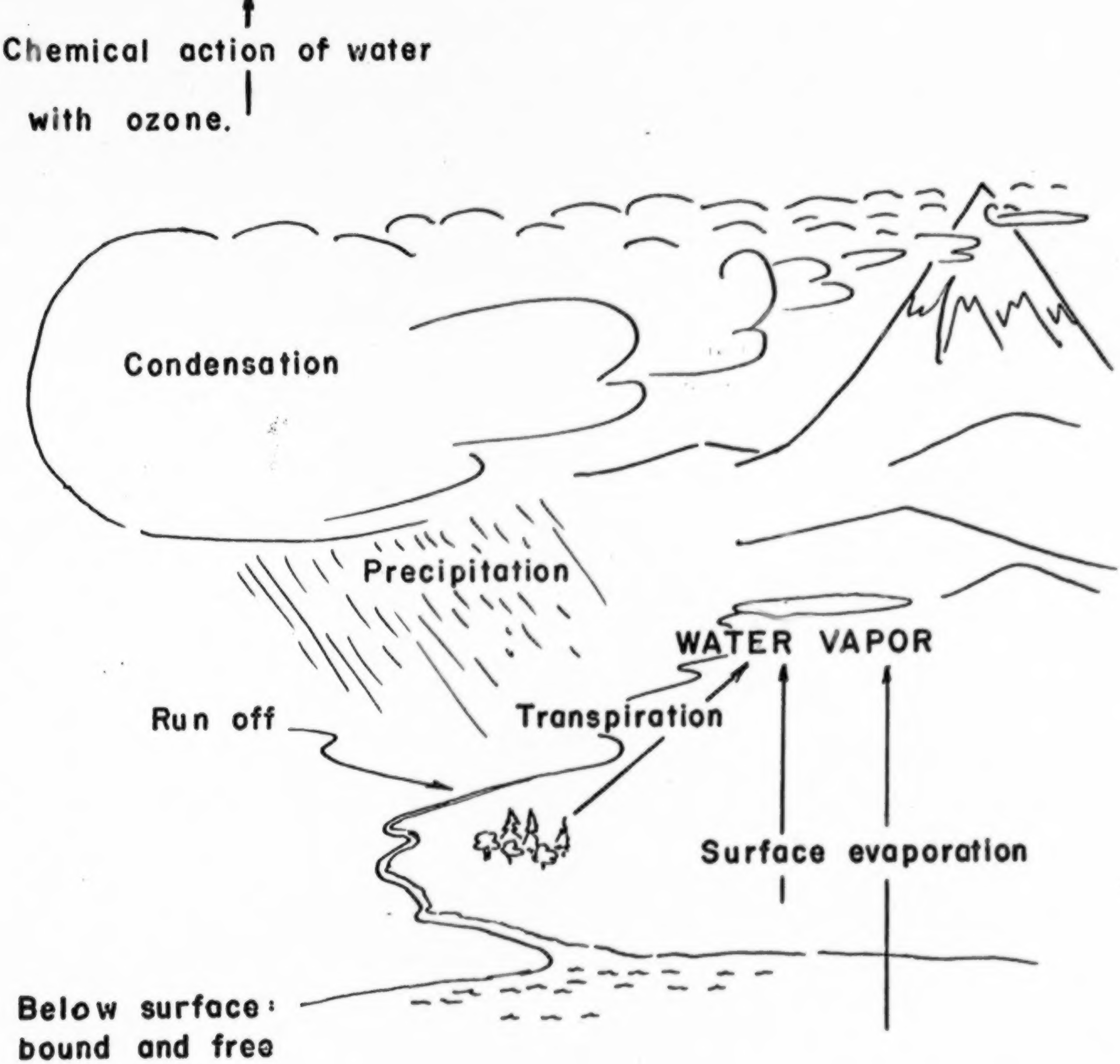
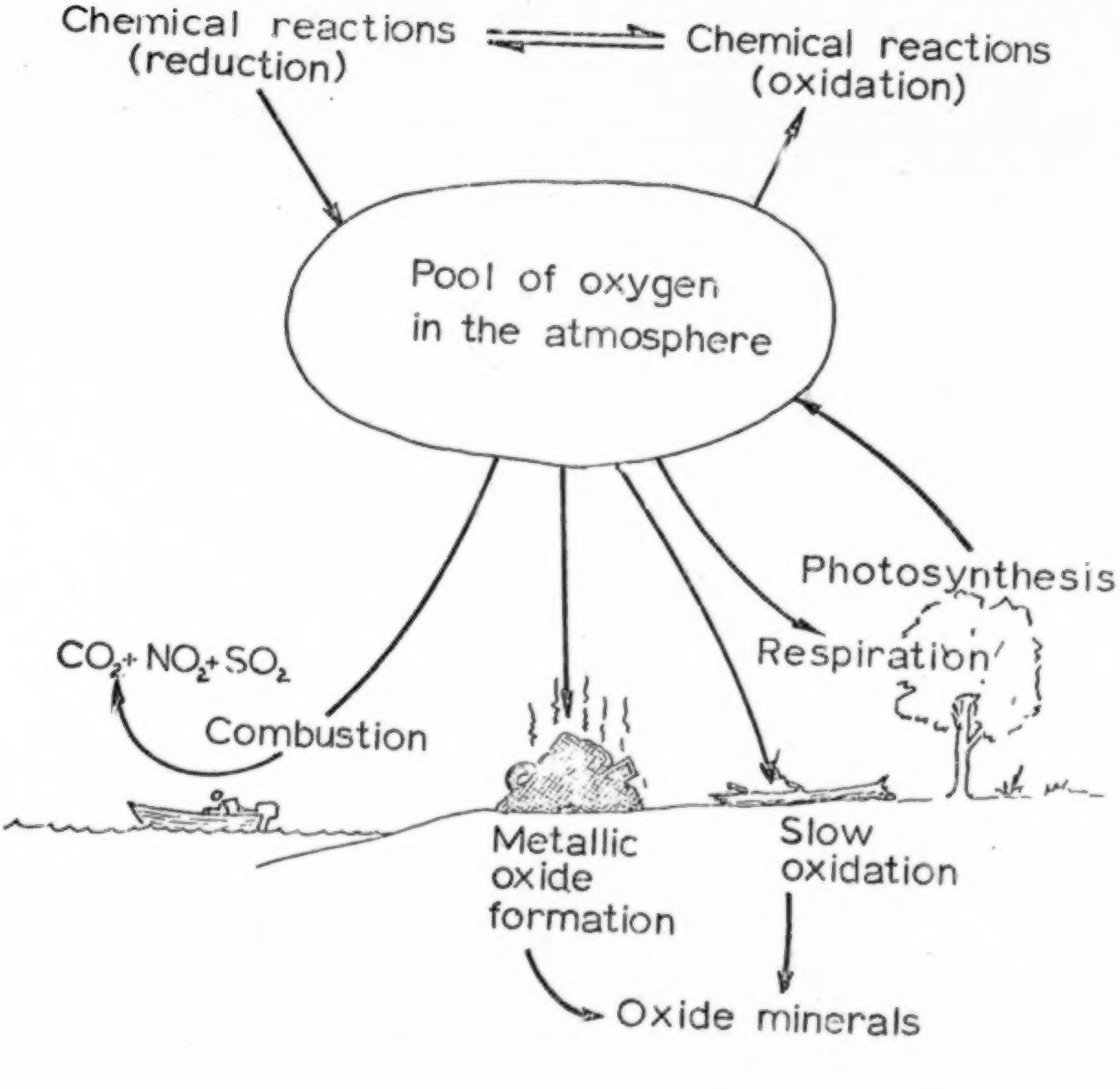

Chemical action of water with ozone.
Condensation
Precipitation
WATER VAPOR
Run off
Transpiration
Surface evaporation
Below surface: bound and free water

Figure 14


Chemical reactions (reduction)
Chemical reactions (oxidation)
Pool of oxygen in the atmosphere
Photosynthesis
Respiration
$CO_2 + NO_2 + SO_2$
Combustion
Metallic oxide formation
Slow oxidation
Oxide minerals

OXYGEN CYCLE

Figure 15

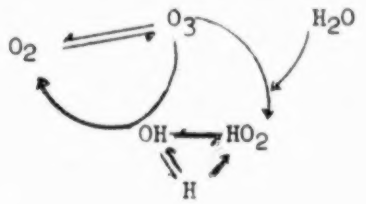
of 1.5 billion cubic kilometers. (A cubic kilometer is approximately 0.24 cubic miles). Of this total, 97% is estimated to be in the form of ocean water. About 2.2% of this is in the solid state, primarily in the ice caps, and the balance is distributed among fresh water bodies, ground water, biologically fixed water, and water vapor. Water molecules of sufficient energy content continuously escape from the surface of either the liquid or the solid phase, creating a gaseous phase. Water in the gaseous phase in the ambient air is of immediate concern in a study of air pollution. The concentration of this water vapor in the air varies from 1 to 3% (10,000 to 30,000 parts per million) depending upon temperature and the availability of evaporation sources.

Several pathways are available to water vapor. As has been previously indicated, it may condense on particles in the air forming droplets large enough to precipitate. In the process, many air particles are washed out of the atmosphere. Often, in cases of severe pollution, clouds of water droplets with impacted, or enclosed pollutant particles, remain suspended in a sustained overcast, or smog.

That portion of the water which precipitates on land, along with its suspended particulates, may become part of the ground water. Part of this water is rather permanently attached to soil particles as "bound water," while some moves through the soil until it reaches the water table, or the level of free water in the soil. This underground reserve of water may move gradually through underground routes back to streams, lakes, and oceans. Much of the water rises by capillary action, or diffusion through small channels in the soil, until it evaporates from the surface of the soil or enters plant roots. Of that portion which enters the plant, only about 1.5 parts per 1000 by weight become incorporated in the tissues of the plant. This biologically bound water, however, constitutes 85-90% of the mass of living cells and it is held until the plant or animal dies and decays, or is converted to a consumer product. The balance of the water entering the plant is lost by evaporation into the atmosphere. The bulk of this loss is by evaporation through special openings, termed stomata, in the leaves of higher plants. This process is termed transpiration. Respiration of both plants and animals, as well as the combustion of fuels of organic origin, return water vapor to the air.

Some water vapor reaches the stratosphere where a special reaction occurs with the ozone present at that level (see equation 9). This is limited under normal conditions, by the quantity of water vapor at this level.

Equation 9



Large quantities of water vapor could conceivably reduce the ultraviolet absorbing ozone layer.

5. Oxygen Cycles

Oxygen, by all indications that we now have, was not a component of the initial atmosphere of the earth. Free oxygen was first generated by photosynthetic, one-celled organisms over 2 billion years ago. Originally these organisms obtained energy from reducing oxygen-containing compounds, such as sulfate, and eventually they acquired the capability of releasing energy by the splitting of oxygen from water. The excess of oxygen diffused into the atmosphere, increasing gradually to the 20.98% level currently existing.

Atmospheric oxygen participates in several cycles. At the tropopause, it enters into the formation of ozone, in the presence of ultraviolet radiation (see Figure 15). The pool of O_2 is also fed from the ozone-water reaction previously mentioned.

In the process of photosynthesis, both by aquatic plants (plankton, etc.) and terrestrial plants, oxygen is produced in the light phases by the dissociation of hydrogen and oxygen. The amount of oxygen thus produced is estimated by Brocher and others to be 256 grams per square meter of the earth's surface. This amount corresponds nearly exactly to the amounts used by plants and animals in the process of respiration. The time required for the total cycle, from molecular oxygen through the biosphere back to molecular oxygen, is estimated to be approximately 2,000 years.

$$H_2O \xrightarrow{\text{visible light}} [O] + 2H^+$$

Some concern exists over the effect of burning fossil fuels and dumping wasters of high biological oxygen demand on the oxygen supply. Such activities produce local deficiencies in eutrophied streams and confined areas, such as city streets; however, there is no evidence to indicate that the current supply of oxygen can be seriously depleted by these activities.

II. Societal Aspects of Air Pollution

A. Introduction

The control of air pollution, and the larger environmental degradation problem of which it is a part, is a social problem: a problem that is intertwined with the values and the world views that make up our culture. To deny this, to refuse to examine our culture, our ethics, our social environment, all of which have unwittingly created the problem, is to perpetuate the thought processes which have brought us here. To assume that "science will find a way" is to take a fatally narrow view of the problem. Science itself has relinquished to the social scientists the "subset" of problems (population, nuclear warfare, environmental pollution, etc.) which confronts modern man.

Environmental deterioration is the result of a complex interaction among multiple social, individual, and technological factors, which have created our urban industrialized society. A society's values are shaped by its conception of the universe in which it lives. An anthropocentric view of the world, which separates man from the rest of nature, allows him to "torture nature's secrets from her." We have a linear view of time, in which there is a belief in an historical progress from a primitive state, upward, accomplished by fighting a resisting universe. This has spawned a feeling that technology and industrialization are the panaceas for all of mankind's ills. This cultural heritage has produced a phenomenally high standard of living in material terms leaving man "rich in means," but impoverished in terms of "ends."

In order to view the situation as a whole, it is necessary to examine some basic concepts about our social as well as our physical envoronment.

B. Historical Perspectives

Man's most successful economic system is a complex market system, characterized by a vast exchange of goods and services between buyers and sellers, known as free enterprise. Other economic systems exist, but none provide so remarkably well for man's wants and needs.

It is only fair to point out that, aside from the American system, the socialist system has also led to environmental deterioration.

Global energy use rose from 3-1/4% annually, during the years 1860 through 1958, to a record 19% for the period 1961 to 1964. The rate of industrialization of underdeveloped regions and world-wide population rise, should produce a higher increase in future years. Energy production rose by the same figures during the period 1961-1964. The increase in high energy economies in the United States, U.S.S.R., and Europe, resulted in the rise in energy consumption (see Figure 16).

Free enterprise is the result of a long period of development based on man's practice of conducting trade for the material items that he did not or could not provide for himself, but which were available from other parts of the earth. Evidence exists that such trade has been carried on since at least the last Glacial Age. Even at that time there were traveling salesmen engaging in basic economic activities.

Concepts of economics developed because men's wants exceeded the gifts of nature, and their "appetites" led to a general condition of scarcity. This, stated simply, is the idea that each man desires something which he does not have, or cannot obtain, because of its low availability; the concept of worth applies here, since anything in scarce supply acquires a certain value. The condition of scarcity is satisfied when someone, somewhere, has an excess of what other men want, or he is able to produce it. It is then "sold" to the man in need for the highest "price" offered for its use or ownership.

Scarcity presented society with two problems: it had to provide for the production of enough of the right goods, and it had to manage their distribution. Until the end of the Middle Ages, provision for the production of goods and determination of the ultimate consumer was relatively uncomplicated. Those who had authority, or power, merely commanded or commissioned production, either for their own consumption, or for whatever ends they deemed desirable, by whatever methods were normally [illegible]

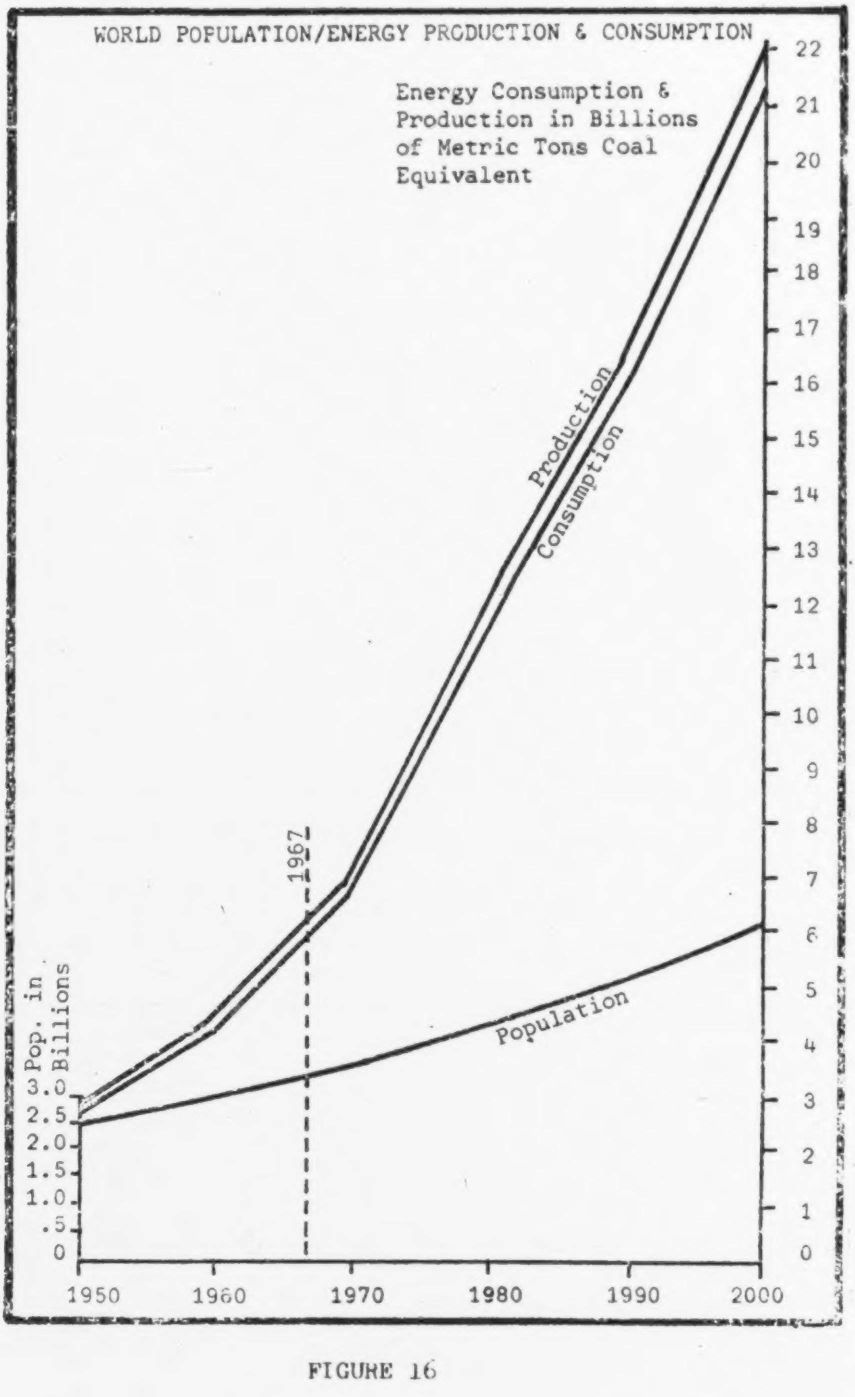

WORLD POPULATION/ENERGY PRODUCTION & CONSUMPTION
Energy Consumption & Production in Billions of Metric Tons Coal Equivalent
Production
Consumption
Population
1967
Pop. in Billions
3.0
2.5
2.0
1.5
1.0
.5
0
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1950
1960
1970
1980
1990
2000

FIGURE 16

their reigns or tenures.

Power derived from energy conversion is now the key to the industrial expansion of highly populated, less developed, regions. This is not a stop-gap need for food, but a need for transportation, communications, distribution, industrialization and education.. (Figure 17 shows that the use of muscle and dung as sources of power are useless to the rapid industrialization of a nation.) Our timber resources are so depleted and so necessary in other crucial areas that they can no longer be allowed to be used as fuel. Throughout the entire world, coal has been replaced by oil and natural gas as the major source of power. Oil and natural gas will continue to rise in absolute terms as total world energy demands continue to expand. Coal will be used only if it becomes economically feasible to tap the less productive supplies available. Nuclear energy is the only new source that is currently expected to make a significant contribution to solving energy needs during the latter quarter of the 20th century. The fast breeder reactor may be available late in the 20th century. This reactor will eventually produce more fuel than it consumes.

At the onset of the Middle Ages, wars, famine, and disease shattered the fabric of European societies and these societies withdrew into self-sufficient units in order to survive.

The subsequent gradual emergence of societies from the Middle Ages coincided with a gradual change from the independent, fragmented, self-sufficient, feudal system to one dominated by new attitudes. Money making became an aspect of business activity. Money became necessary for labor goods and land. Demand and supply became factors in the production of goods and services. This change in attitudes continued until the consumer, not the people with authority or power, exercised economic control. Money

WORLD CONSUMPTION OF FUELS

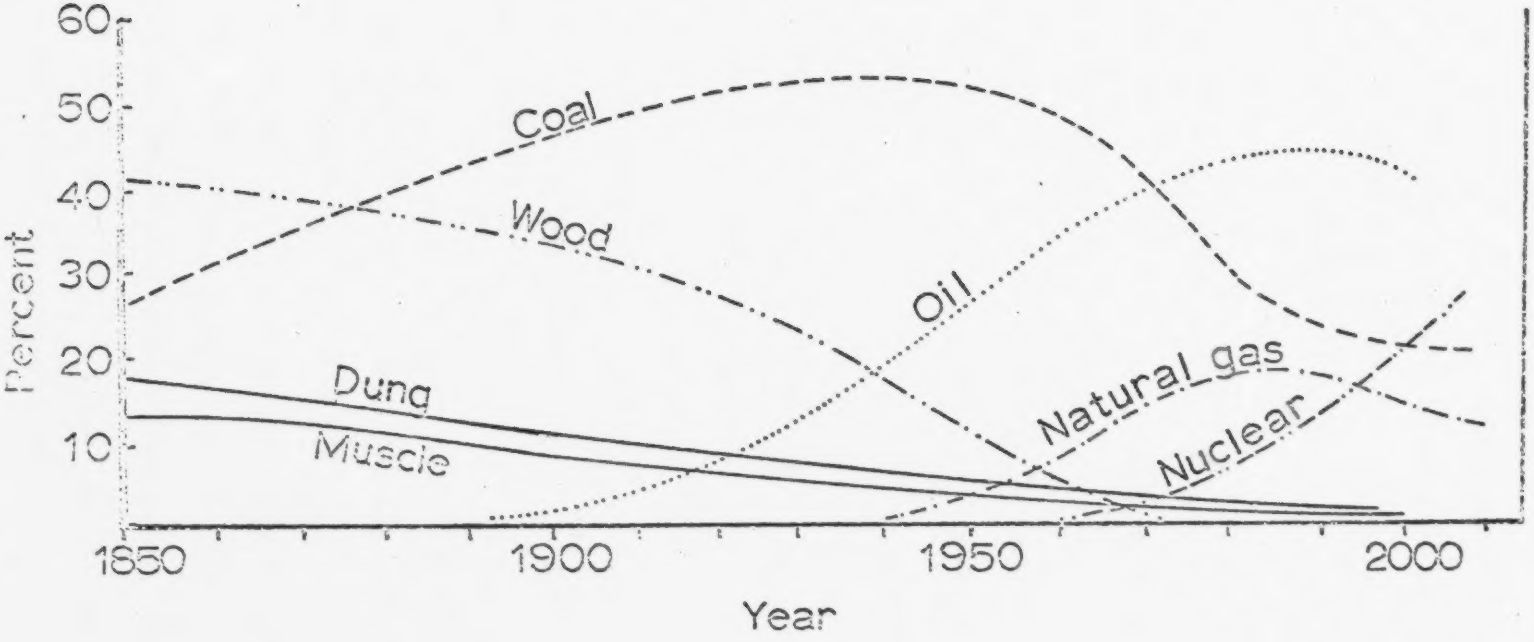


Figure 17

became the principal medium of exchange, and the profit motive - the maximation of income and the minimization of expenses became established as a legitimate incentive for business.

Pollution of the earth's atmosphere was not a significant threat to man's health and well-being, during this long period of change, because agriculture and commerce were still the principal basis of economic activity and the population was small. However, this period of transition led directly to the Industrial Revolution, which began in England as a result of favorable attitudes toward commerce, scientific discovery, and technological innovation. The Industrial Revolution caused social upheavals and important changes in society. It brought about the creation of factory and industrial slums, increase in urbanization, increase in the degree of individual interdependence, awareness of economic growth, and the beginnings of the present atmospheric pollution situation.

Society's application of science and technology to the production of goods and services (first to textile machinery, then to mining, agriculture, power production, transportation, electronics, space explorations...) initiated a steady increase in industrial output. This led to the elimination of much poverty within industrial societies, and the eventual rise in the standard of living has continued to the present time - a standard heretofore unknown to man. An air pollution situation heretofore unknown to man has also arisen as a result of industrialization.

One can see that life expectancy of industrial man far exceeds that of primitive tribal man (Figure 18). Primitive man primarily slept or worked. An agricultural man found some time that could be devoted to creative and leisure activity, but little need for formal education. The great increase in the formal education of industrial man paved the way for a tremendous amount of creative and leisure time.

With the technological revolution one finds a commensurate [illegible]

LIFE TIME ACTIVITIES

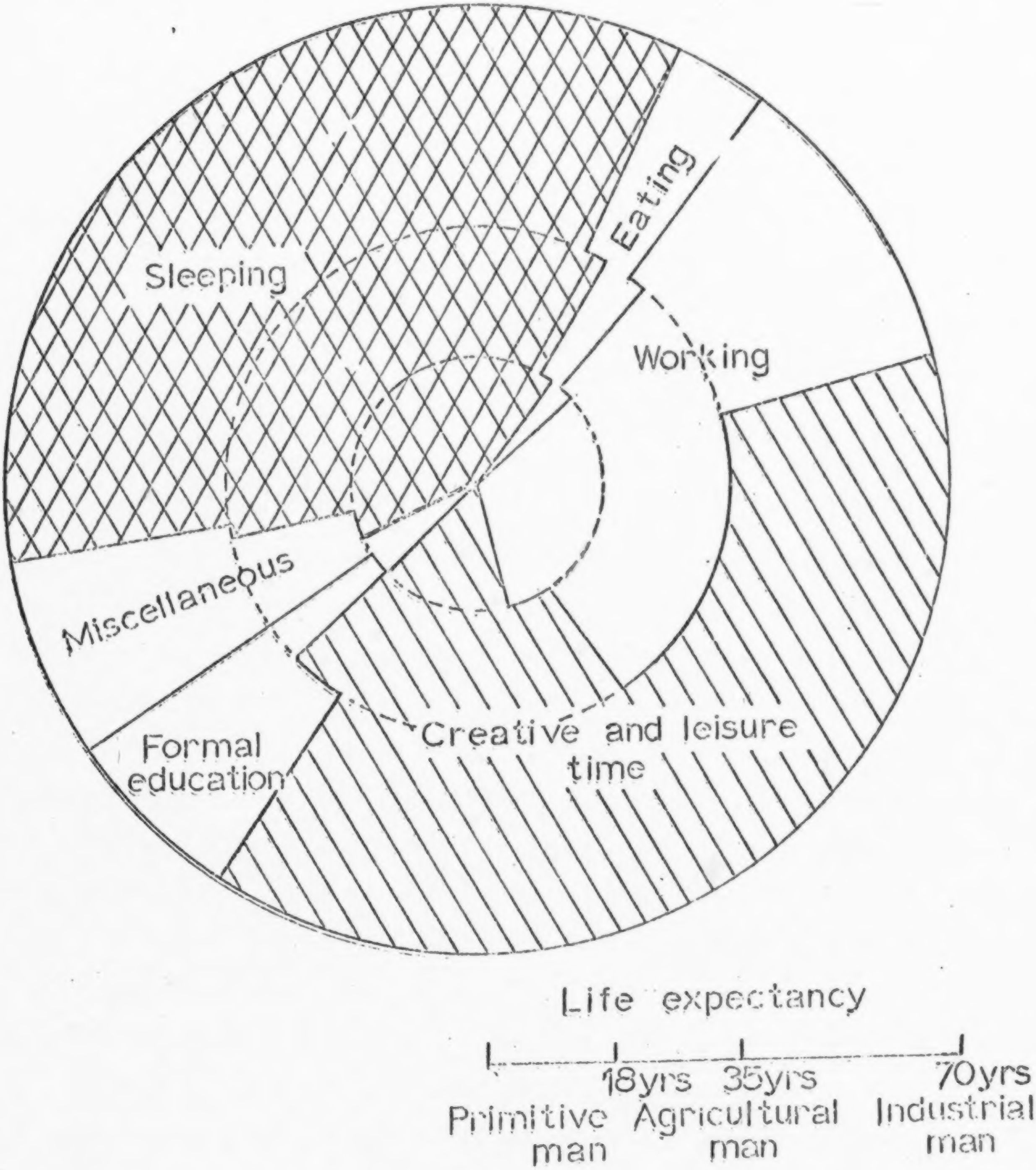

Sleeping
Eating
Working
Miscellaneous
Formal education
Creative and leisure time
Life expectancy
18yrs
35yrs
70yrs
Primitive man
Agricultural man
Industrial man

Figure 18

LABOR FORCE DEPLOYMENT IN AN ADVANCING ECONOMY

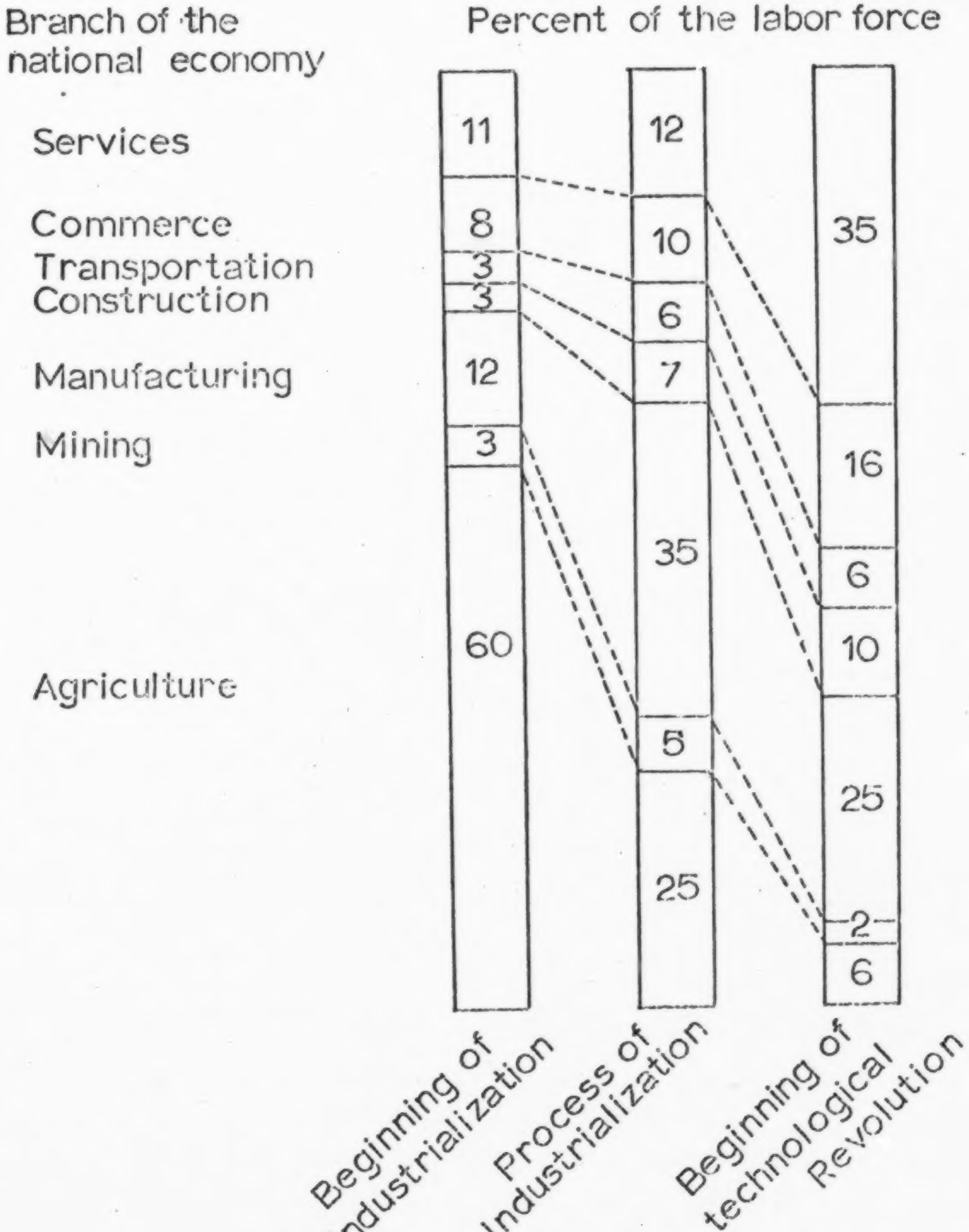


Figure 19

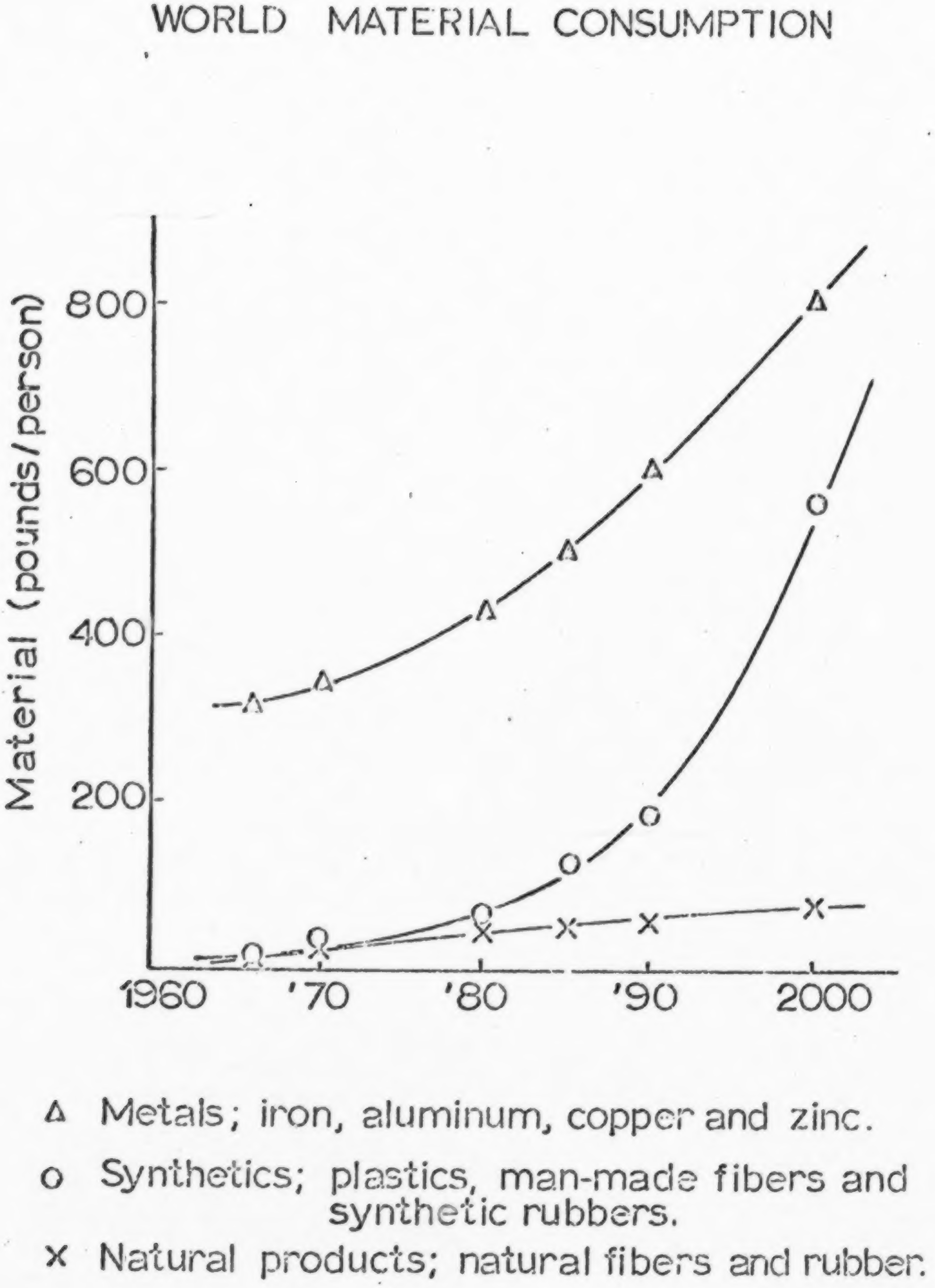

WORLD MATERIAL CONSUMPTION
Material (pounds/person)
800
600
400
200
1960
'70
'80
'90
2000
Δ Metals; iron, aluminum, copper and zinc.
o Synthetics; plastics, man-made fibers and synthetic rubbers.
x Natural products; natural fibers and rubber.

Figure 20

in the agricultural labor force needed to sustain the population (Figúre 19). The need for raw materials remains about constant, but the emphasis is shifted. Figure 20 points this out dramatically; either natural products are not sufficient or they cannot be obtained. Greater dependence is placed on synthetic products or metals - especially the rare, exotic metals. Furthermore, 35% of the technological labor force is needed to provide services with a less rapid increase in the force needed in commerce, transportation, and construction. The latter three items produce their own share of modern man's problems, especially in cities.

The present air pollution situation has been developing for approximately two hundred years. It has caused, principally, by the growth oriented production of the goods and services which have contributed to the relatively high standard of living currently enjoyed in this and other industrialized countries of the world.

Perhaps the greatest impact of industrial technology was the internal combustion engine and its application to transportation. Consumers' demand for this invention, and the production of automobiles and other motor vehicles resulted in a redistribution of the work force, the subsequent rise of unionism, the economics of large-scale production, and the eventual conception of industrial and commercial monoplies.

Use of motor vehicles resulted in great changes in the living habits of society and the viability of traditional urban centers. Supplying the demand for motor vehicles has created employment and income for a large sector of industrial societies. However, the greatest single source of atmospheric pollution has been the operation of these same motor vehicles with their fossil-fuel burning internal combustion propulsion units.

C. Society is a System of Relations Among Individuals

We find ourselves in a society in which there are many systems interacting rather than existing in isolation. The tunnel vision of each system must be replaced by dimensional vision, which appreciates this relationship.

Our society is characterized by interdependence instead of the nurtured myth of independence. In any system composed of two or more units, relationships are such that changes in one unit affect others. The larger and the more complex the system, the more difficult it is to predict the effect of change in a specific unit upon all other units.

Do we have liberty or freedom? In the Platonic definition, liberty is the removal of restraint; i.e., doing what is good for me! This is the theme of the pioneer, the hippie, and the corporate businessman. The pioneer polluted and then moved on to new territory; the hippie wanted to be free to "do his thing," irrespective of the impact on the entire social group. Obviously, "whatever is good for General Motors" or General Electric must be good for you.

It is to be noted that socialistic man pollutes as blindly as the most greedy entrepreneur. Corporations have gone to great lengths to develop individual consumer-preference through advertisement. This is most easily recognized, whereas collective preference (i.e. that for clean air) is not as easy to see. Secondly, in the past, all environmental pollution has been externalized by the polluter. This means that the costs are not borne by the producer of the product; for example: a chicken farm started next to a health resort. However, all public goods, like land, water, and air, are collectively consumed, and the environment requires collective solutions.

In the Aristotelian definition, freedom is the ability to make a decision or a choice for the good of the group. If the environment is made uninhabitable, one does not have freedom; there is no choice or decision to be made. The important idea to grasp is that only through a group effort can we achieve success in cleaning up our environment. This is achieved at the expense of the individual's liberty.

In the case of an individual vs. an environmental polluter, "standing in court" must be demonstrated by the plaintiff. This means that a person in New York cannot sue an oil company in the Gulf of Mexico for damages to the environment. There are also very few ways to establish esthetic damage to property. Should such a case come to trial, a verdict against the plaintiff would set precedent for future cases. A case in point is that of Boomer et. al. vs. Atlantic Cement Company (case No. 55M, 2nd 1023). Boomer sued for damages to his property and an injunction to stop the company from polluting. He won damages, however, after receipt of damages he lost standing in court in regard to further damages from the same source. This is tantamount to giving companies the right of eminent domain, formerly only the right of government.

In 1968, Garrett Hardin published an article entitled, "The Tragedy of the Commons." The commons is a fundamental social institution which recognizes that there are certain environmental entities which have never been and should never be appropriated to any individual or group of individuals. The commons was just that in England, an area of land set aside for public usage. The tragedy was the overgrazing which resulted from individuals adding "one more cow" to the herd. The profit to the individual was large, and the deterioration to the commons minimal, until the same conclusion was reached by every herdsman.

In a populous society, we must regulate the use of the commons for the general welfare. The real danger lies not in the laws but in their administration. There is enough documentation to build a model for what will occur in a society:

a. A general outcry produces a regulatory agency.

b. Political quietness develops among the majority, which has a general, but unorganized interest in the commons.

c. The interested groups bring pressure to bear through any political processes which would tend to convert the agency. These groups protect the commons from incursions and further their interests.

d. The staff of the agnecy is finally drawn from the ranks of the regulated.

D. Society has Seldom Foreseen or Questioned the Long-Range Consequences of its Action.

Cultural conditioning has produced patterns of thought which value the short-term over the long-term. Long-term effects have gone unquestioned in favor of the immediate or short-term benefits. There is a need to examine certain culturally-produced axioms by which our society has functioned --"economic growth is the measure of all good;" "eternal progress is possible in en infinite world;" "what planning there is should maximize production and resource exploitation." We seem to have placed more importance on the fact that men live in the short-term rather than appreciating that "the collective man" can exist only in the long term.

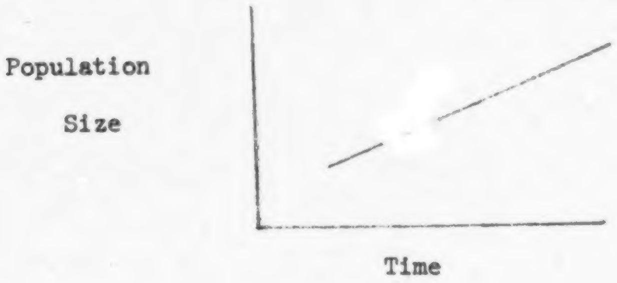
There is a need to view new technological triumphs in the light of what their effects will be on human life. Western culture can no longer view man as separate from and above nature. The simple use of cadmium in the electronics industry, without proper safety factors in indefensible. The knowledge that cadmium can be inhaled and transported by the blood stream, resulting in its replacement of calcium in the skeletal system, demands protective measures (see section on non-ferrous metals).

Society's head long rush to improve the environment by passing and enforcing appropriate legislation can be tragic indeed. We recognize the effect of phosphate excesses on the ecology of a body of water. We do not anticipate the consequences of corrosive substitutes. Nor does nature stand still while a pesticide is being banned by governmental procedures. The dynamic system responds to the decrease of controls and the insect population grows at an increased rate. Do we want to make commensurate the control of "equine encephalomyelitis" and the freedom of the commons from DDT?

Our present individual activities must be examined in relation to the rest of society. We need to consider the possibility that technology is a "double-edged sword," able to help and to harm. Does the organized pursuit and realization of technological progress act to destroy the chief ingredients that contribute to man's well-being? The levels of various pollutants can be determined, economic damage estimated, methods of controlling pollution can be established, and a price tag can be placed on cleaning up the environment. But what level of clean air is desirable when contrasted to the other pressing environmental problems of housing, nutrition, or hospital services? If the air is clean, is our environment necessarily more healthful?

If we neglect the input of solar energy, we are living on a finite earth which contains finite resources. The law of conservation of energy, or the First Law of Thermodynamics, tells us that we may optimally expect a 100% transformation of energy from one form to another. This means that we have a finite amount of material resources to support a population. We may use an economic equation that says population size is equal to a constant times the inverse of the standard of living. A large population can be supported if we accept the lowest possible standard of living. The Second Law of Thermodynamics states that a 100% energy transformation is impossible. Some energy is always wasted or unattainable, and we are forced to support a lesser number of people or subscribe an even lower standard of living.

Uncontrolled population tends toward an equilibrium in birth rates at 45 per 1000 population; whereas, deaths tend to occur at a constant rate of 35 per 1000 population. In the following graph we are plotting population size vs. time; the slope of the graph equals a growth curve.



if our population exceeds our resources, the population declines. When the population size is lower than that allowed by the resources available the population increases more rapidly than the slope for an undisturbed society. A population could, if it were sensitive to the environment, determine for itself when it has passed the equilibrium point because the symptoms of overpopulation begin to occur - malnutrition, disease, psychological disturbances, and environmental damage. When change in an ecosystem occurs more rapidly than a species is able to adapt to, the species faces extinction. Examples of the stresses that can cause extinction are food scarcity, climatic change, competitive disadvantage, or a sudden natural cycle imbalance.

Possible cures for over-population may be summarily lumped under two headings, "birth control," or increased death rate. Faced with these alternatives, man must make a moral decision - should he reduce births or face an increased rate of deaths, often beyond his control.

Most approaches to the problem of population control revolve around the attainment of zero population growth. Achievement of Z.P G. for the U.S. will result from a drop of the current birth rate from 17.4 per thousand to about 13.0 per thousand. Once Z.P.G. is reached, the population size will level off and remain constant as long as public support of the program is general. This approach is not a total solution to overpopulation, since the population size may still be in excess of the resource base supporting it, and a negative population growth rate may have to occur; no agreement exists or is apt to exist as to what the ideal population size should be.

E. Society may need to change, modify, or adapt human wants which are in themselves, reasonable and defensible.

We must come to the recognition that the terms reasonable and defensible are relative ones - their meaning can shift with time. Human wants that were at one time justifiable may no longer be so in a physical world of limited resources. The means by which human wants traditionally have been satisfied (increasing technology, conquest of nature) need to be looked at in the light of scientific and social evidence of their consequences.

We know that life is damaged by present social conditions but we all participate willingly or unwillingly in a system that despoils the earth and exacerbates human relationships. We are unwilling to give up the personal advantages derived from the conditions which we know are objectionable.

> Americans do not seem to be willing to let the utilities continue devouring these ever-increasing quantities of water, air, land. And, yet, clearly they are also not now willing to contemplate doing without all the electricity they want. (Jeremy Main, "A Peak Load of Trouble for the Utilities," Fortune, Nov., 1969).

Does every new automobile, highway, air conditioner, electric can opener create more problems for society than they solve?

The proper flow of materials is now as essential to the maintenance of the human society as it is to the maintenance of natural cycles. However, the economic system is operated in large sectors in terms of a barter system characteristic of an agriculturally based society. Most of the resources in current use were not even recognized as such fifty to one hundred years ago. Our current dependence on key metals, many of which were regarded as waste impurities in other ores, is a result of the manner in which we conceive them to be. We need to redesign our major social, industrial and agricultural procedures toward a more effective means of functioning.

a. A faster, more efficient recycling of the materials in the system.

b. A greater dependence on natural energy processes and a saving of our fossil fuels.

c. A refashioning of our food cycle to produce the most efficient natural means of food conversion while decreasing our dependence on large volume fertilizer and pesticide usage.

d. An establishment of early warning systems which will study the immediate and long-range effects of technological undertakings on the quality of the environment. Complete studies will need to be made concerning all of the costs of all societal function -even the social costs of the intangible effects, including the esthetic. The inclusion of all such costs may possibly prevent certain manufacturing or construction processes by rendering them uneconomical by new benefit-cost standards.

F. Social impetus for solutions can only come from the large group.

Because of the characteristics of the problem and because of human nature, it is almost impossible to visualize solutions being accomplished on an individual or small-scale level. The problem is such that "there is no one factor that by its removal or control alone will lead to the ultimate solution." (Cassell, Eric J., "The Health Effects of Air Pollution and Their Implications for Control," Law and Contemporary Problems, Duke University School of Law, Spring, 1968). Individual actions must be combined to press for solutions.

1. By its nature, air pollution calls for public action, since air is a public commons subject to overuse, and it is difficult to trace pollution from one source to one receptor.
2. Air pollution has no political boundaries. Air contaminants frequently cross state lines and contribute to a condition of pollution in a neighboring state.
3. The danger of creating "pollution sanctuaries" argues for broad-based action because "emitters who have established strong economic positions as they polluted the air usually feel that they have also built up pre-emptive rights which ought not to be taken from them." (Earl Finbar Murphy, Governing Nature, p. 186).
4. Human nature and its tendency to minimize the problem undermines broad action.
    a. "The real question is whether the sense of public concern is enough to persuade people to sacrifice certain private goods for the suppression of public

bads." (Kenneth Boulding, "No Second Chance for Man," The Progressive, April, 1970, p. 41.)

b. "When we use the word responsibility in the absence of substantial sanctions are we not trying to browbeat a free man in a commons into acting against his own interest?" (Gilbert Hardin, "The Tragedy of the Commons," The Environmental Handbook, p. 45).

c. Restrictions, controls, sanctions, appeals to conscience must apply to all, or ultimately, they will affect the behavior of none.

Our obligation to future generations may need to be redefined; progress in a direction favorable to human welfare will need to be maintained. Whatever restraints are placed on men will have to be placed on them with their concurrence, and will have to be such that they do not destroy man's sense of worth and security.

III. Activities of Man Contributing to Air Pollution

A. Introduction

Man's activities have led to a higher standard of living as a consequence of his efforts to satisfy basic physical and psychological needs. Industrialization was a necessary consequence of the effort to fulfill man's felt needs and led to a technological society that produces an enormous amount of energy and material necessary to sustain us at our desired standard of living. Over the past 30 years the energy needs for every American man, woman and child has more than tripled. Currently, these human activities result in a production in excess of 209,000,000 tons of air pollutants per year, or over one ton of pollutants per person.

We use approximately thirteen tons of material per person each year. Over a long period of time people and businesses do not consume goods. All goods are eventually either discharged to the environment or cycled back into the production process. An understanding of the kinds and sources of atmospheric pollution is necessary to assess their collective defiling effect and desired control measures.

In terms of the atmosphere, only two categories of pollutants exist: gaseous and suspended particle additions to the normal air. While these things do occur naturally, by and large, pollution is the result of man's activities. Similarly, whether a particular substance is judged a pollutant or not is a consequence of man's attitudes. It is often very difficult to assess the role of any one gaseous or particulate additive to the natural atmospheric state unless it is present in exceptional quantity (e.g. SO_2 in an industrial center).

In looking at the political and economic implications of air pollution and its control, there are some general considerations that apply to all of man's pollution-creating activities.

The economic dilemma arises from the historical fact that until recently, air has been regarded as free and the cost of its use for waste disposal has seldom, if ever, been a consideration. It has been precisely for this reason that the atmosphere has been so widely used as a disposal medium.

Politically, the problem is compounded because of the various levels for administering controls (federal, interstate, regional, state, local), the difficulty in arriving at and enforcing satisfactory standars, and the fact that air sheds do not usually conform to traditional political boundaries. To date, the federal government has been more inclined to take a relative back seat in the push for air pollution control; it is willing to step in only when it has been demonstrated that the state and/or local machinery cannot arrive at a satisfactory solution of the problem.

Industry has indicated that it will actively pursue pollution control if all have to live under the same regulations. Their desire for laws with wide applicability comes from the fear which each company has that the "good-guy" who has to raise prices to pay for cleaning up his operations will suffer competitively with the "bad-guy," who has not bothered.

B. Primary Industries

1. Mining

a. Overview

The history of the copper and bronze ages indicates that man has, for an appreciable time, been able to extract and refine our natural raw materials. The Roman Empire established a thriving trade with the British Isles for mineral resources. Later, the industrialization of countries led to the establishment of factories close to natural resources of power and mineral wealth. Open pit and then deep mining, as surface deposits became depleted, became prevalent. Deep mining became practical as ventilation and automation were improved. The requirement for cheap fixed costs led to the exploitation of fossil fuels as a source of power. Closure, limited amounts of land in Western Europe, famine and political unrest (wars) led to large emigration, which provided a large labor force that could extract natural resources very cheaply.

The first evidence of concern with air pollution was the suggestion by Pliny the Elder that workers in mining and grinding operations wear protective masks. Since Pliny's time, expansion of mining operations, increased deep mining, increased use of mechanical devices such as the pneumatic drill, and many other factors, have led to greatly increased air pollution and eventually an increased concern over the nature of such pollution and its deleterious effects.

b. Sources, Hazards and Controls

Drilling, blasting, handling operations, and wind erosion are the major sources of particulates from open mining. The appropriate use of wet methods and consideration of meteorological conditions can control the dust, but add to water pollution! Deep mining effluents can come primarily from exhausting of mine air into the outside atmosphere and can be controlled by appropriate filters. However, poor disposal of dust (stockpiles) may lead to the dispersal of particulates by wind. Furthermore, chemical reactions can occur in stockpiles of slag with the resultant production of hydrogen sulfide, and underground fires that cannot be extinguished. Many of these fires have been burning for over 15 years and in addition, they are diminishing the structural support of the earth. A recent study shows that there are five hundred mine fires burning concurrently in 15 states.

The U.S. Public Health Service indicates that 142 uranium miners have already died from radiation overdoses. This danger is predominantly due to radon gas, which may cause an additional 600 to 1100 uranium miners to die of lung cancer within the next 20 years.

The control of dusts being emitted from uranium mines and stockpiles is very important. The radioactive wastes can attach to dust particles on the ground or in the air. These dust particles are then trapped by the moist surfaces of the air passages in the lungs. Long-term exposure may lead to carcinoma of the lung. The proximity of the radioactive dust particles to cell tissue will destroy or modify the cell in a short time span, either by beta or gamma emission. Alpha emission injury requires entrance of the emitter through ingestion, or through epidermal breaks.

The disposal of all uranium mill trailings is another serious problem. The common practice is to use the refuse for construction fill. In some isolated instances, the radiation levels measured in the houses built on this fill are so high that the homes must be evacuated.

Coal mining operations produce large amounts of dust from refuse and coal storage piles. A major hazard results from the fact that particles from 1.0 to 0.1 microns remain suspended in inhaled air and are irritants in respiratory diseases, such as silicosis, bronchitis, and emphysema (see Table 7). With every breath, we inhale particles up to five microns in size, which will reach our lungs. Certain dusts change healthy sponge tissue to useless fibrous or scar tissue. Silicosis is the most general disorder and has gone by the names grinder's consumption and rock tuberculosis. Usually characteristic fibrous nodules develop and increase in size up to about four millimeters. As a result of loss of spongy material, shortness of breath, difficulty in breathing, chest pains, and a racking cough are commonly experienced by the individual. The more advanced the disease, the greater the susceptibility to infection of the lung tissue.

Fortunately, the body has some primary defenses such as cilia, tonsils, hair, sneezing and mucus. Referring to Figure 21, one finds that the hair in the nose filters out particles. The contours of the nasal cavity cause particles to come in contact with the cilia and mucus membranes. Diffusion also aides the removal of particles as they pass through the trachea. The filter system of the nose removes particles greater than 10 microns in diameter. Particles from 2 to 10 microns will usually settle on the walls of the trachea. Only particles between 0.1 and 2.0 microns are likely to reach the alveoli. Particles less than 0.3 microns, if not absorbed by the blood, will be exhaled from the lungs.

In spite of all the mechanisms, particles still lodge in the alveoli. This may be preceded by bronchial asthma (see Figure 22), where excessive secretion of mucus in the bronchial tube obstructs the air way. This results in recurrent coughing and difficulty in breathing. In extreme cases, the alveoli become enlarged due to a loss of elasticity. This disorder is termed emphysema and it is the most common disease of the lung. Air becomes trapped in the lung and cannot be expelled. Shortness of breath and extreme difficulty in breathing result.

TABLE 7

Particulate Sizes for Different Particle Types

Size

	Small (.01-1 u)	Medium (1.0-100 u)	Large (greater than 100 u)
Type of Particle	smoke	fine sand	liquid spray
	metallurgical dust	fly ash	coarse sand
	carbon black	coal dust	drizzle
	fine talc	paint pigments	fertilizer
	insect dusts	insecticide dusts	ground limestone
	salt nuclei	pollen plant spores	large organic fragments
	aerosol mists	milled flour	
	colloidal silica	bacteria	

THE RESPIRATORY SYSTEM

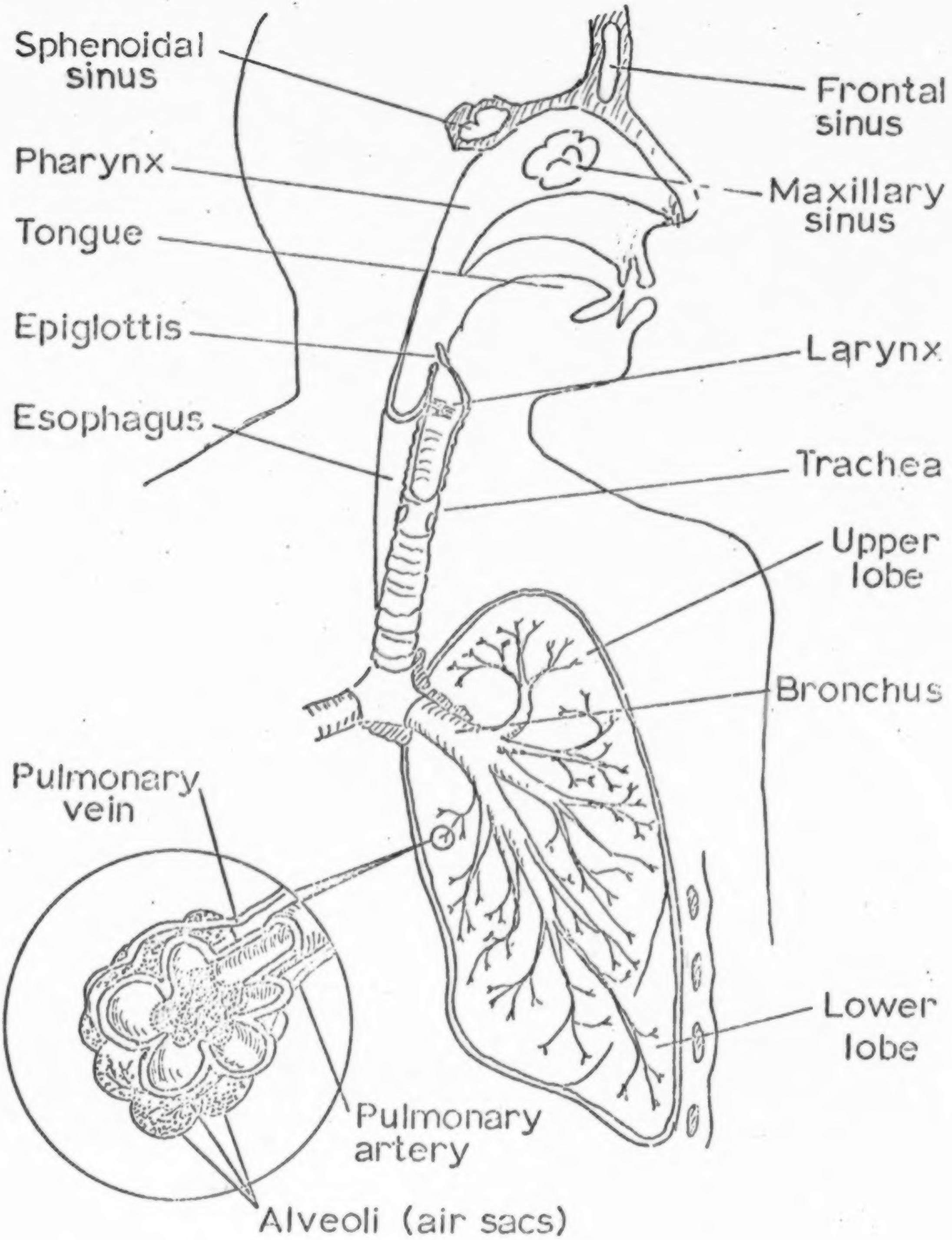
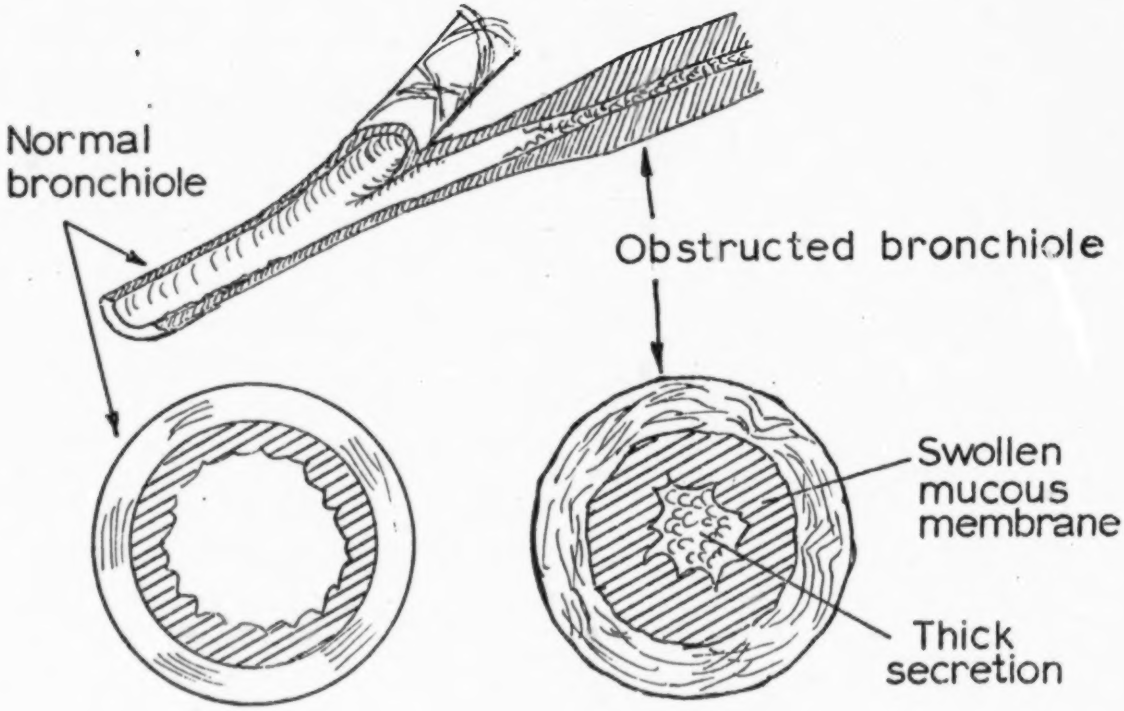

Sphenoidal sinus
Frontal sinus
Pharynx
Maxillary sinus
Tongue
Epiglottis
Larynx
Esophagus
Trachea
Upper lobe
Bronchus
Pulmonary vein
Lower lobe
Pulmonary artery
Alveoli (air sacs)

Figure 21

BRONCHIAL ASTHMA


Normal
bronchiole
Obstructed bronchiole
Swollen
mucous
membrane
Thick
secretion

PULMONARY EMPHYSEMA

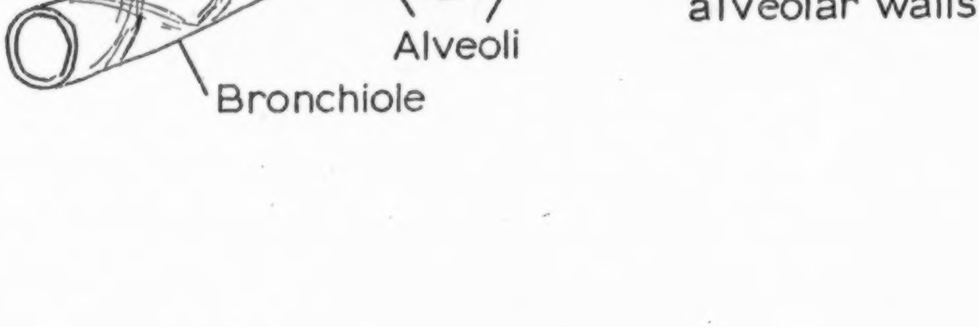

Trapped air
Broken-down
alveolar walls
Alveoli
Bronchiole

Figure 22

2. Agricultural Activities

a. Overview

As a society progresses from an agricultural economy towards industrialization and an automated technological economy, there is a continual movement of people to urban areas. For example, in England (Circa the age of the Tudors), landholders became aware that raising sheep to supply the burgeoning textile trade with wool was more profitable than raising crops. Consequently, a series of closure acts were passed, and many farmers were thrown off their land, which was in turn pre-empted for sheep. These farmers gravitated to the cities. A parallel can be drawn between this forced migration from the country to urban areas and our modern American migration.

Gradually, the Industrial Revolution, with its concentration of materials and manufacturing in single plants, led to higher wages and continued migration to the urban areas. These conditions prevailed not only in Europe, but increasingly, after 1800, in the United States. The Industrial Revolution continued, accelerating the movement from country to city, after each major war.

In the U.S., a steadily increasing industrialization provided the lure of jobs and higher wages in urban areas, again decreasing the farm population. With the application of technology, (mechanized farming, agricultural chemicals, and genetic improvement), it became possible for fewer farmers to farm increasing amounts of land to feed a larger number of people.

The introduction of the methods of technology to farming increased production to the point where farm profits decreased, necessitating help for the farmer in the form of subsidies - land bank programs, and price supports. The increased profits that could now be obtained resulted in accumulation of large amounts of acreage, increased automation, and use of pesticides. The development of hybrids and disease-resistant strains of plants added to the unit productivity.

b. Sources, Hazards, and Controls

One of the perils of so many rapid changes over a relatively short period of time can be seen if we recall the soil erosion in the Middle West and South West during the 1930's. A latent dust problem may be created through improper soil preparation and use. The conversion of range land into wheat land in Kansas and Oklahoma led to dust storms that were carried to the eastern seaboard of the U.S. Furthermore, the production of specialty products (white asparagus), application of fertilizers and soil conditioners occasionally creates localized dust problems, which can be controlled by wind breaks, proper time of application, and proper cultivation procedures.

Natural desert conditions and wind accompanied by low rainfall can produce dust storms. According to L. Battan (Unclean Sky, Anchor, 1968), Sahara dust can be found on all parts of the globe. (The enlargement of the Sahara Desert in the past century is a phenomenon that needs additional investigation). Man's activities (travel, grazing, building) may churn the desert and produce conditions conducive to continual dust storms. In fact, city suburbs in desert valleys are major sources of dust. Diffusion and absorption of light can become so intense that the sun may appear red to the viewer. Dust, which is really displaced soil, creates much pollution on its own. Additionally, airborne toxic materials, principally pesticides, are usually incorporated with the soil particles and add to the problem.

Spraying of pesticides also produces aerosols which, depending on their diameter, may drift substantial distances from their source.

TABLE 8

Horizontal Drift of Particles

Size	Drift
vapor	indefinitely
less than 5 u	many miles
10-50 u	several miles
greater than 100 u	80% less than a mile

At present, the best method of control is to coordinate spraying with meteorological conditions.

Still more air pollution may be caused by indiscriminate use of burning as a means of disposal of agricultural waste. Private burning of weeds, leaves, and horticultural refuse is generally banned by air pollution laws in metropolitan states. However, commercial agricultural enterprises are generally exempted from the provisions of such statutes. Prescribed fires in the southeastern pine forests are examples of large-scale burning of this type. In this instance, burning is employed prior to planting of seedlings to remove weeds and brush, to facilitate planting, and to lessen the hazard of uncontrolled fires during the early years of the forest. Removal, chipping, and landfill operations are expensive alternatives to these burning procedures.

Smudging of orchard crops to protect fruits from frost is a great source of pollutants, and it is being controlled by the use of more efficient burners, the requirement of permits and legislative restriction. In California, smudge pots are not permitted. Other alternatives are infrared heaters with reflectors, large wind machines, and flooding or spraying with water. The technique used depends upon the fruit or vegetable in question.

Agriculture has also been under pressure to reduce odor emission as residential areas become contiguous with farmlands. For example, fruit and vegetable growing leads to odorous residue. Old cabbage leaves, dropped fruit and grass silage are notorious for their offensive odors. A common disease, known as Farmer's Lung, may be caused by NO_2 which results from the decay of silage. Dust, containing spores and fungi which are inhaled when handling silage and hay, are common hazards. Also, the raising of chickens, cattle, sheep, and hogs for sale produces a noxious odor problem, particularly due to nitrogenous wastes.

The injection of liquid manure into the ground as a method of disposal is technically feasible, but expensive. The chemical treatment for odors, when the manure is spread above ground, is not satisfactory at present. Also, the run-off water from feed lots leads to enhanced pollution of streams.

Farm animals produce ten times the waste produced by the human population. Good sanitary procedures, including the employment of lagoons for waste disposal, aid in the solution of the problem. Of legal and social interest is the encroachment of housing tracts on rural areas. When livestock is raised under such conditions, it becomes imperative to pen the animals. The feeding lot situation intensifies odors and creates complaints which initiate legal action. Such court actions have raised legal questions of prior occupancy, i.e., the "grandfather clause" problem of much social legislation.

The detection of odors is at best very subjective, since these noxious substances depend upon concentration and duration. Some substances, like hydrogen sulfide, are noxious at very low concentrations (this gas has an odor similar to that of rotten eggs), and they block the olfactory mechanism at higher concentraitons. At these high concentrations, hydrogen sulfide is odorless and very toxic. A further problem to be considered is whether or not the odor affects one's occupation, or whether it is simply an esthetic problem. People seem to be less tolerant of odors, particulates, and noise, if the pollutants are unrelated to their economic welfare. When related to a person's employment, otherwise annoying pollutants are more often tolerated.

The preparation of food for man and animal, which requires milling, mixing, and drying, results in dust problems. Cyclone-type filters and cloth collectors are both effectively used for control (see Figure 23). The cyclone depends upon the incoming gas being guided into a cylinder in such a way that a strong vortex is established. The heavier particles leave tangent to the circular motion on the outside of the cone. Clean gas escapes through a center outlet because of a vortex-created updraft, and the concentrated dust-laden air is withdrawn at the bottom.

The bag filter passes gas at a low velocity through finely woven fabric arranged in tubular "bags." The dirtier the bag, the more effective is its cleaning action. The bags are rapped, reverse-blown, or vibrated periodically to drop the dust into a hopper. In any case, the bags must be cleaned or replaced. If the particles cannot be used in some manner, or recycled, a tremendous refuse problem can result.

The whole food-processing industry produces odors from oxidative rancidity, catechol, and nitrogenous compounds. These products occur when unsaturated oil from fish oxidizes, or when either autolytic processes, or bacterial decay processes occur in proteins composed in part of nitrogen and sulfur. Most of the gases produced are amines. Starches and sugars decomposing under aerobic conditions produce alcohols and acids with unpleasant odors (e.g., lactic acid). Good sanitary practices are an obvious solution.

By-product processing represents the most difficult odor problem. The transportation, storage, and cooking of raw material require expensive equipment to control plant air, and probably refrigeration during transportation and storage. The residues from canning, dehydration, and quick-freezing must be disposed of before an odor problem develops. Anaerobic and aerobic lagoons, sanitary landfill, and incineration, as well as charcoal filters, and scrubbers (see Figure 24), are all being used to dispose of food-processing wastes.

The scrubber can remove fumes, mists, and soluble gases in addition to very fine particles. The one illustrated uses a spray to remove particles and gases, whereas others employ atomizing, dynamic, centrifugal, and packed towers. The major problem is what to do with the resulting polluted water.

Incinerators, of course, create their own air pollution problem. All methods produce solid waste problems. Do we solve one problem by creating another?

3. Silviculture

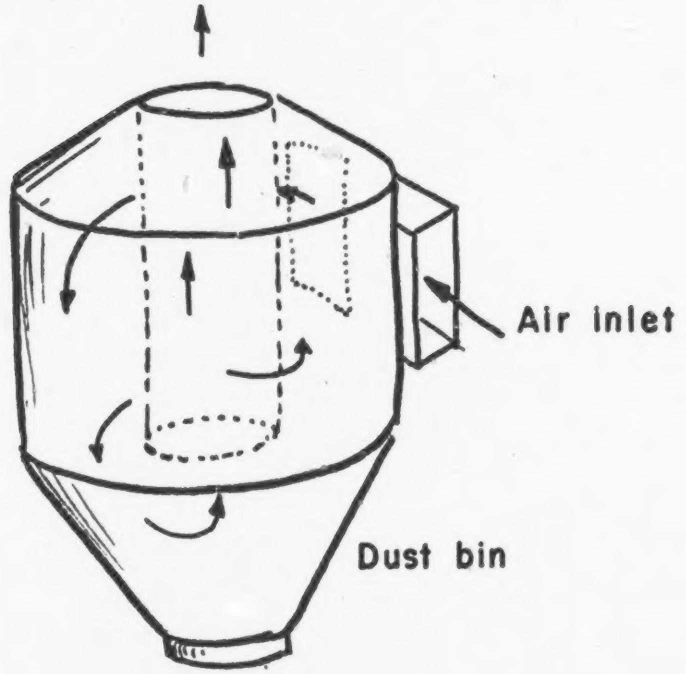
a. Overview

During the colonization of the U.S., the forests were denuded primarily to clear land for farming and to supply timber for the British Navy. The use of lumber as the predominant building material gained momentum throughout the 19th century, which has been termed the "Age of Wood." Until this time, no one, except for a few visionary writers, paid much attention to the idea of conservation. Gradually, concern for natural resources emerged, and by the end of the nineteenth century, a strong conservation movement existed. Initiated by President Theodore Roosevelt and supported by concerned Americans, legislation establishing national parks, forests, wild life refuges, and wilderness areas was passed in the early part of this century. This activity spawned the soil conservation services, as well as the creation of hundreds of state parks and forests.

b. Sources, Hazards, and Controls

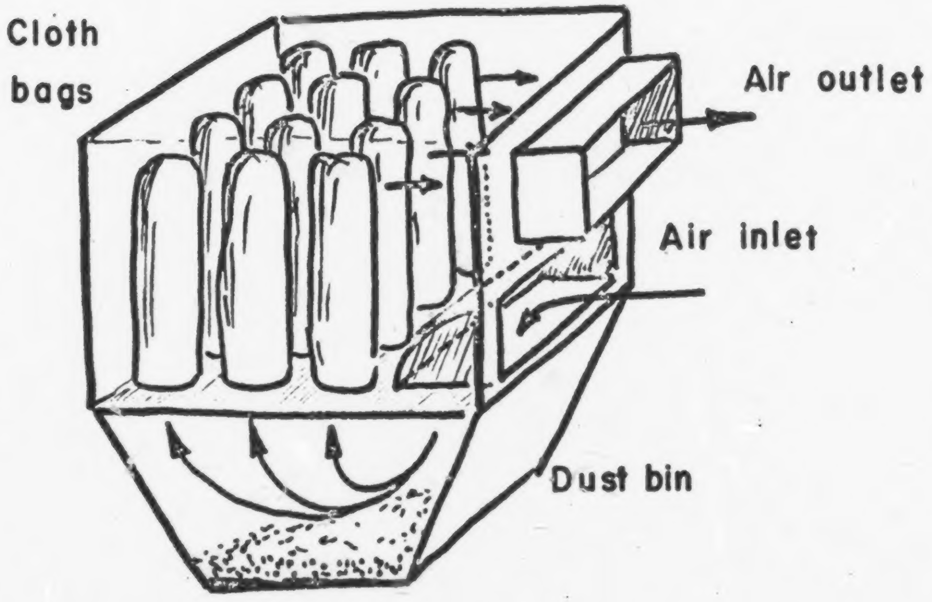
Forests create pollution resulting from both forest fires and the decay of organic material. The pollutants are generally short-chain hydrocarbons (methane, organic sulfur and nitrogen compounds). Pine forests release emissions, known as turpenes, which are then converted to particulates. These particulates are responsible for the esthetically pleasing haze associated with the Blue Ridge Mountains.

Irresponsible silviculture results in an imbalance of natural cycles. The cutting of all trees in a water shed leads to erosion and possible enlargement of arid regions. Changes in the plant community (size of wooded area, types of vegetation) will also affect the structure of an animal community. A study of the Hubbard Brook Forest in New Hampshire, where all the trees in a water shed were cut, indicated that the ion concentration of runoff water from the cut area polluted the streams in the watershed. The use of trees by cliff-dwelling Indians of the U.S. Southwest resulted in enlargement of the desert,



CYCLONE FILTER

Air inlet
Dust bin



CLOTH COLLECTOR

Cloth bags
Air outlet
Air inlet
Dust bin

Figure 23

WET SCRUBBER

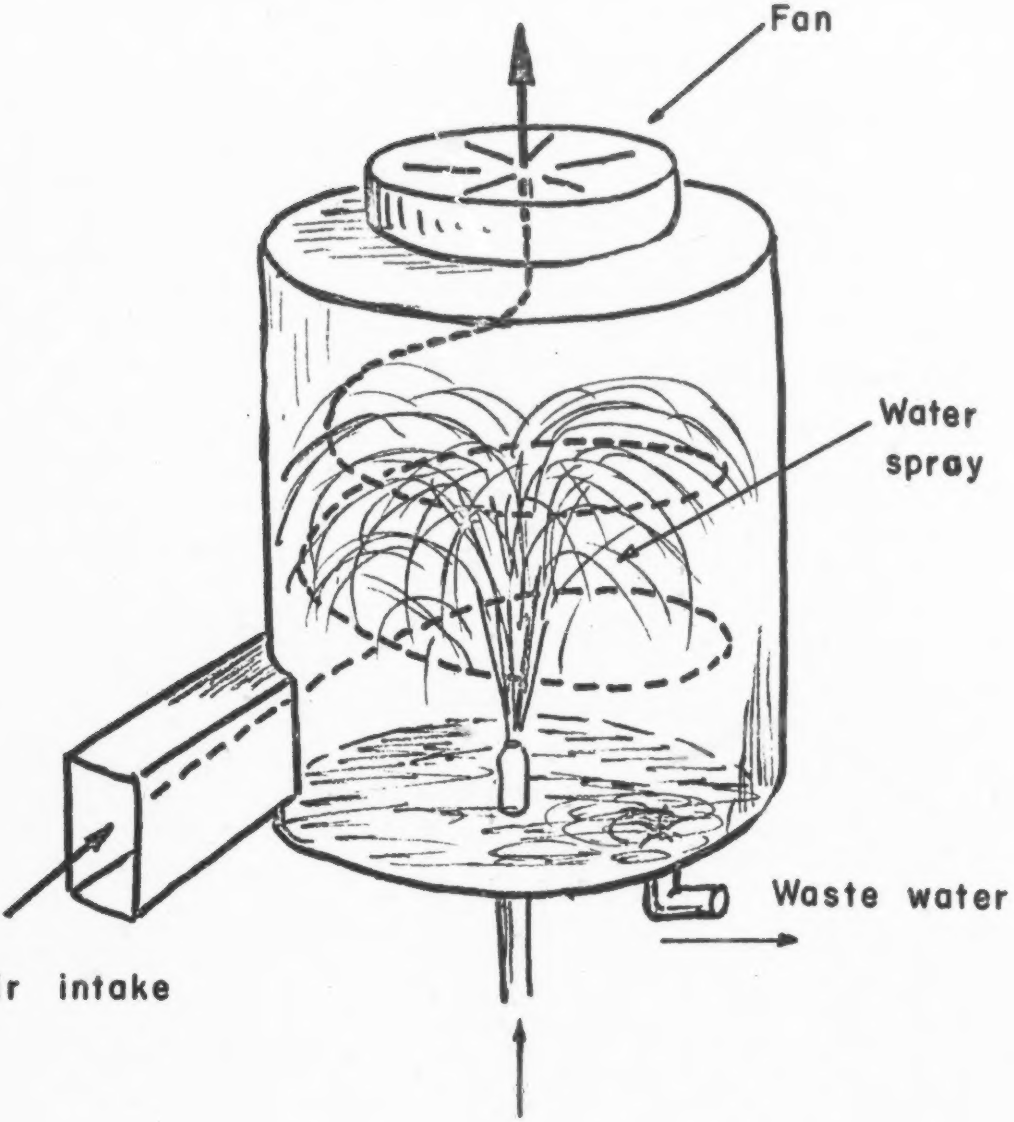

Fan
Water
spray
Waste water
Air intake

Figure 24

and the region has never returned to its former ecological balance.

Fifty percent of the carbon dioxide in the naturally balanced cycle is assimilated by terrestrial plant life. Since improper silviculture, or air pollution, along with removal of vegetation for the purpose of constructing roads and buildings, will hamper the process of photosynthesis global carbon dioxide concentrations may increase at a faster rate in the future (see Figure 25a). According to some estimates, the cumulative effect of burning of fossil fuels as energy sources, and the decrease of green plants as utilizers, could, barring the action of other related variables, raise the temperature of the earth from one to seven degrees. An increase of seven degrees is based on a static model, assuming no increase in water vapor or particulates. Accurate estimates of the variables affecting the dynamic model are not possible at the present, but estimates would indicate something closer to a 1% temperature increase. Up to the present, the temperature has not shown a substantial increase.

The fact that a static model utilizing carbon dioxide has been used in calculations relative to temperature should be stressed. One might also hypothesize that the increased production of light-colored particulates associated with increased consumption of fuels, would lower the global temperature. This would result in an increase of carbon dioxide dissolved in the oceans. The phytoplankton would then be able to photosynthetically fix more carbon dioxide. The carbon dioxide equilibrium would then be displaced in a direction tending to reduce atmospheric carbon dioxide and decrease the "hot house" effect. The resulting lower temperatures, enhanced by the light-colored particles, would again increase the rate at which carbon dioxide is dissolved in the ocean. It is possible that an ice age could result from this dynamic process.

C. Process Industries

1. Power Generation

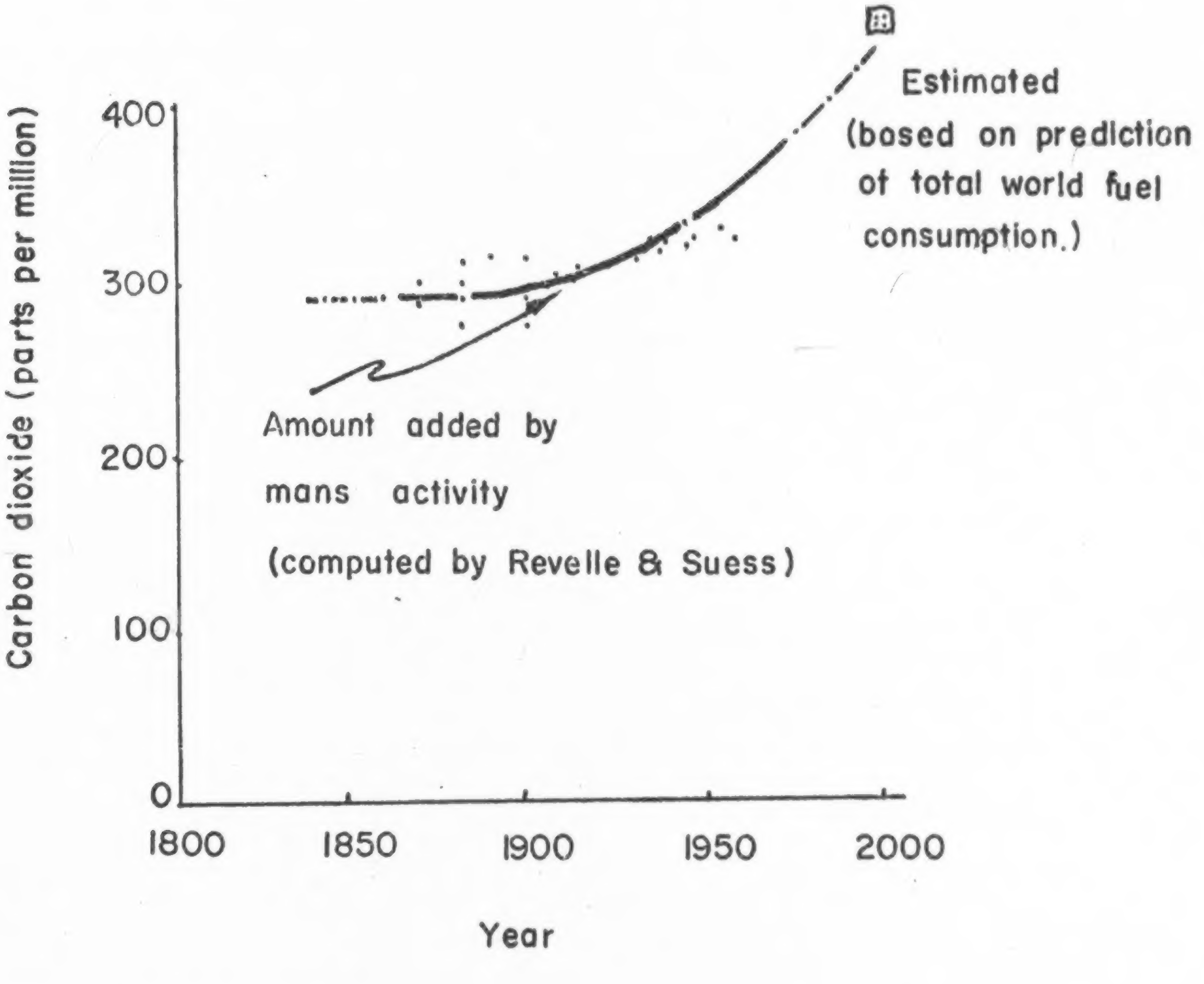
a. Overview

The Industrial Revolution in England (1760-1830) and the United States (early 1800's with accelerated growth after the Civil War) progressed from the use of wooden machines which utilized water, steam, and animal power, to metal machines dependent upon electrical power, or pneumatic power for stationary machine operation. Eli Whitney developed the system of interchangeable parts for manufactured items, and Henry Ford initiated the assembly line. Technological advances, which resulted in automated industrial procedures, required tremendous amounts of power. Electricity is the most efficient form of power for long distance transmission between stationary sources; therefore the demand for electrical power sources increased rapidly.

b. Sources, Hazards, and Controls

The sources of energy that are presently available for the production of electrical power are solar, hydrodynamic, fossil fuels, and nuclear. The use of solar energy is largely limited by climatic factors. Unfortunately, air pollution in some areas which might otherwise be able to utilize solar energy, sometimes creates too much interference with solar radiation to permit the development of solar energy as a resource. The increased use of water power is hindered by the ecological ramifications of damming water sheds, and by the inefficiency of long distance power transmission, as well as land conservation problems.

THE SECULAR INCREASE IN CARBON DIOXIDE



1962 value of CO_2 = .031 % of air by volume

2000 value of CO_2 estimated at .045 %

Figure 25a

Here and there engineers are trying new approaches to the problem of water power. Engineers in France, for example, are trying to harness tidal energy as a means of generating electrical power. However, unless there is a major innovation in hydroelectric power, we seem to be limited to using fossil fuels and nuclear reactions as sources of energy for power generation (see Figure 25b). One can see from the graph that by the year 2000, barring cahnges in usage patterns, natural gas as a source of energy will exceed nuclear energy and be approximately equal to the energy derived from coal. Hydroelectric power and nuclear energy are projected to produce about the same total amount of energy. Compared with all energy sources, hydroelectric energy will constitute a mere 12% of the total world primary energy production by 1990.

Electric power plants produce approximately 24% of the total air pollutant emissions in the U.S. during 1970.

The major pollutants emitted were the sulfur oxides, with nitrogen oxides and particles of secondary importance. Coal-fired plants produce over 90% of the sulfur oxides and particulates emitted by power-generating plants. The production of carbon dioxide, not considered an air pollutant, is produced primarily by power-generating plants, and the internal combustion engine. Estimates for the annual emission of carbon dioxide in the United States show a 33% increase between 1800 and 2000. The passage of legislation in large urban areas requiring the burning or organic fuels containing less than 1% sulfur content has already decreased the SO_2 concentration to 60% of the 1965 levels. Figure 26 gives the relationships between gaseous pollutants and their sources. Table 10 shows that the particulate problem is basicly caused by space heating, and municipal and on-site incineration.

The oxidation of SO_2 to SO_3 and consequently the production of sulfur acids in the atmosphere, require about a four day time period. Sulfurous and sulfuric acids, causes deterioration of metals, limestone, marble, leather, cotton, wool, and other materials either through dehydration or the formation of sulfate salts. Plant and animal damage occurs by reaction of SO_2 with water in the tissues. The gas enters the plant through the stomata, and the first indication of damage is typically necrotic (dead) spots about these stomata (see Figure 27). The palisade and spongy cells may also be affected.

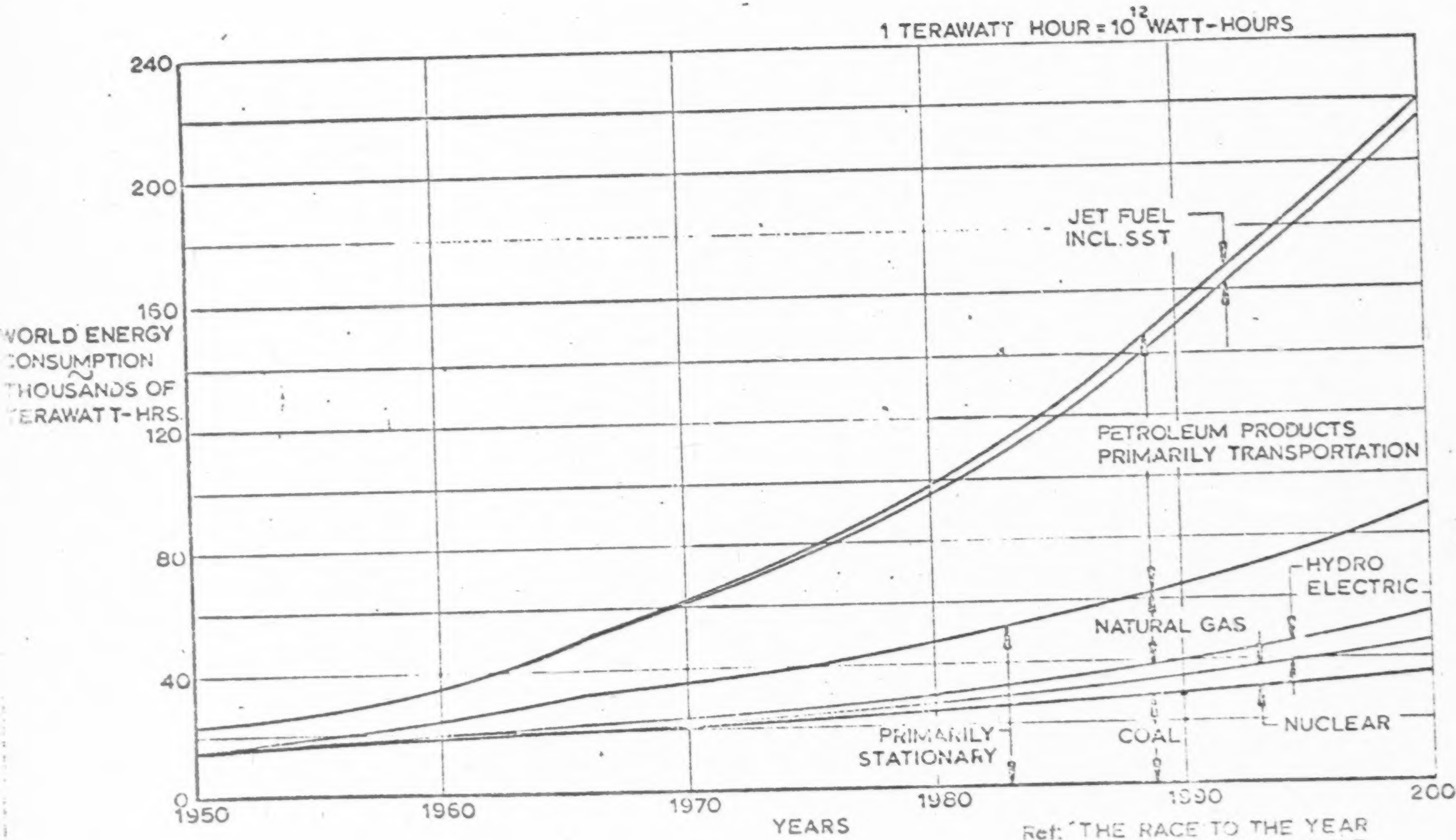
Sulfur dioxide, reacting in this fashion, is one of the gases most toxic to plants. Near Ducktown, Tennessee, an area of vegetation was destroyed and the soil was chemically affected by the effluent from a copper smelter. Fifty years after this incident, the area remains barren. Acute injury to plants by sulfur dioxide typically occurs above 0.25 - 0.30 ppm over a one to two hour exposure. Chronic exposure may result in injuries at concentrations between 0.10 and 0.30 ppm. Table 9 gives sensitivity of some selected plants in order of increasing resistance.

TABLE 9

Plant Resistance to Various Concentrations of
Sulfur Dioxide Over Long Time Periods

Increasing Resistance ↓

Plant	Concentrations
Clover, Trefoil	.15 - .2 ppm
Corn, beans, spinach Roses, strawberries	.2 - .3 ppm
Cabbage, soybeans	.3 - .4 ppm



Ref: "THE RACE TO THE YEAR 2000" by FRITZ BAADE.

Figure 25b

WORLD PRODUCTION OF
PRIMARY ENERGY (1950 TO 2000)

U.S. AIR POLLUTION; KINDS, SOURCES & AMOUNTS (after U.S. Dept. of H.E.W., 1970)

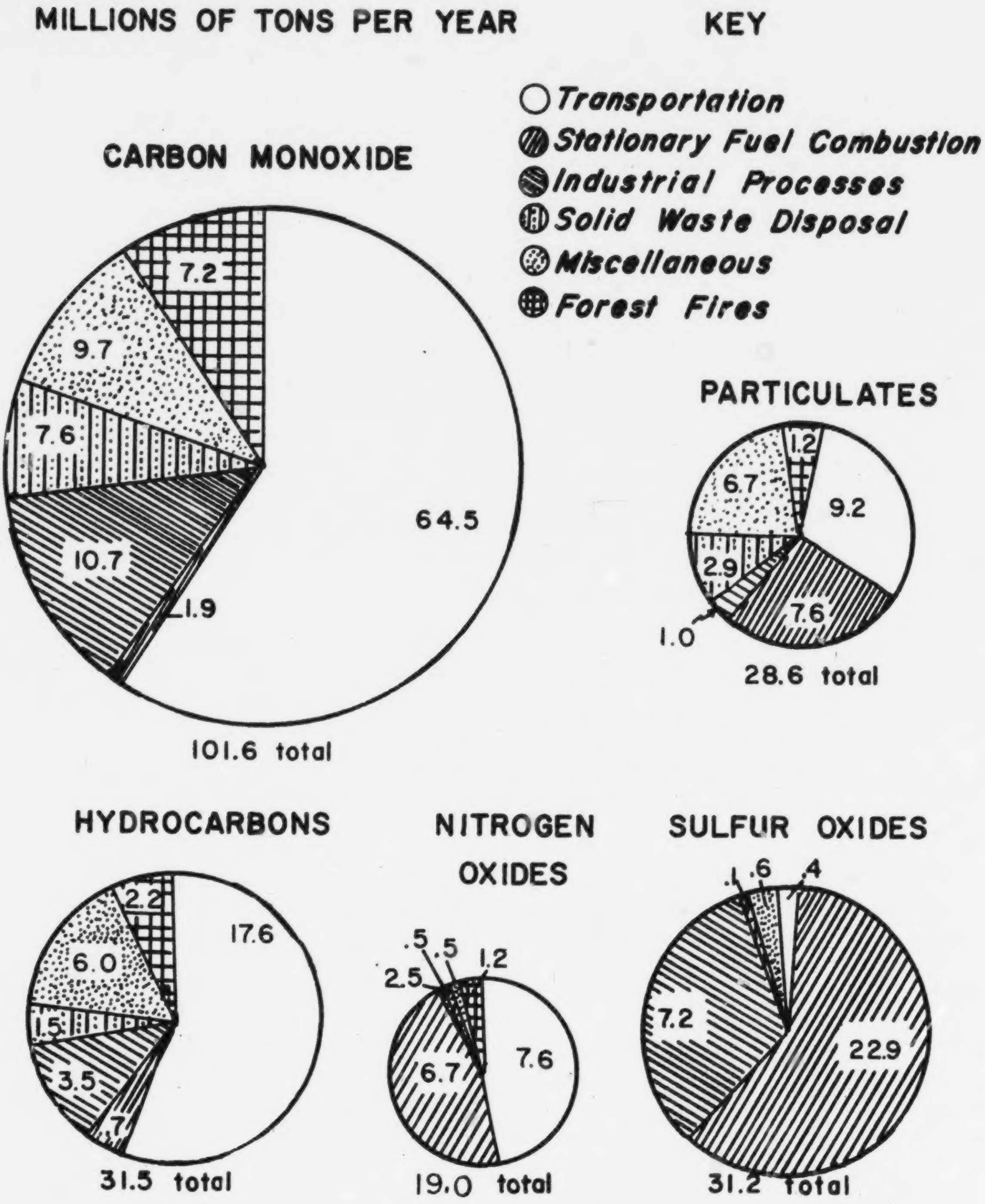


Figure 26

DIAGRAM OF A LEAF IN CROSS SECTION

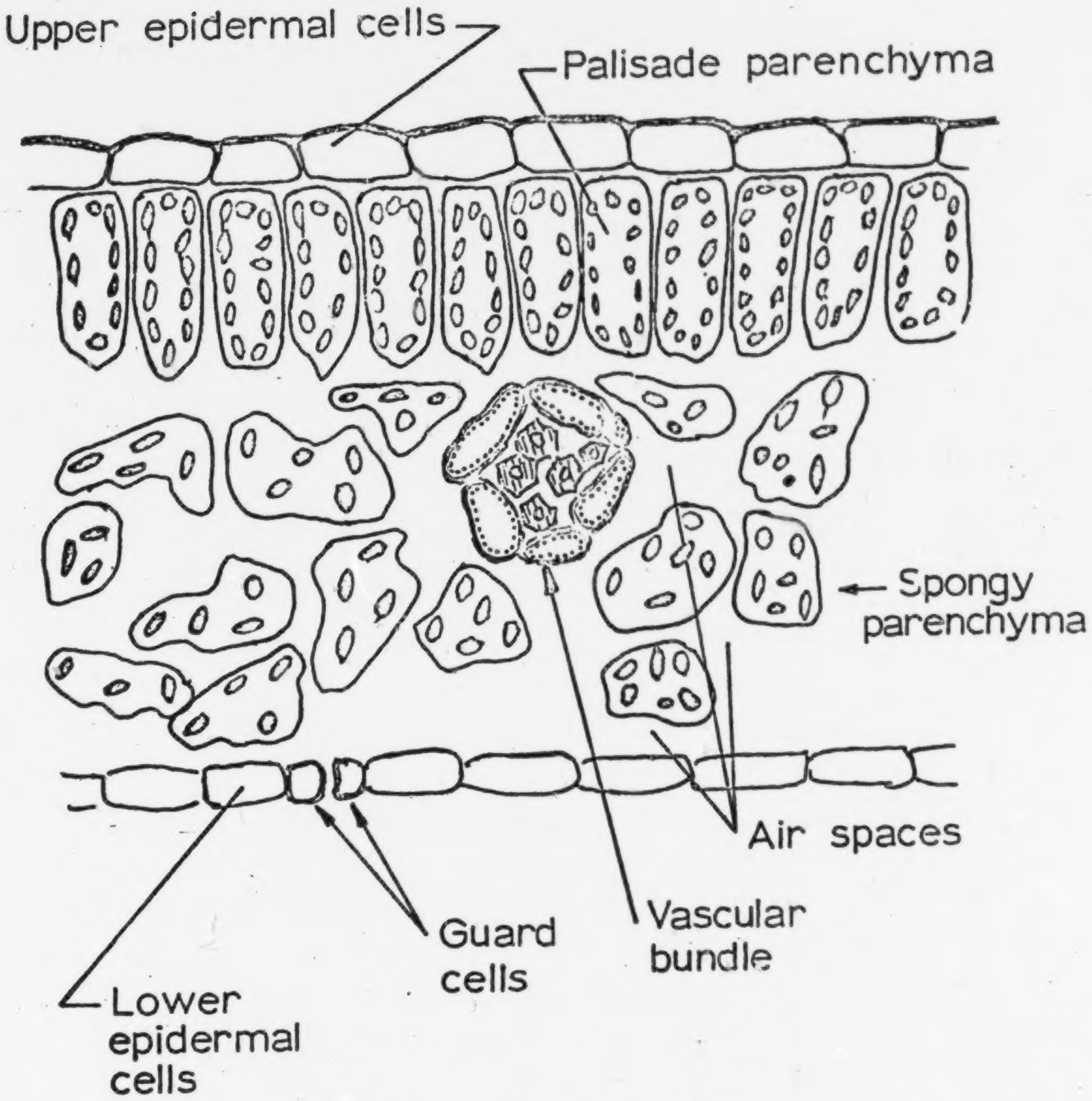

Upper epidermal cells
Palisade parenchyma
Spongy parenchyma
Air spaces
Vascular bundle
Guard cells
Lower epidermal cells

Figure 27

Some investigations are being conducted on the effects of two or more gaseous pollutants upon a plant's resistance to damage.

TABLE 10

Analysis of Sources for Dust and Soot in New York City: 1969

Sources	% of Total
Space heating	32.3
Municipal incineration	19.3
On-site incineration	18.4
Mobile sources	14.3
Power generation	9.2
Industrial sources	6.5
Total tonnage/year	69,120

Table 11 lists health effects of various concentrations of sulfur dioxide. This gas is an allergenic agent with respect to bronchial asthma. In the presence of smoke, 0.21 ppm of sulfur dioxide is associated with deterioration of physical well-being of urban dwellers. Toxicological data seems to indicate, however, that not SO_2 but SO_3 may be the harmful compound.

The elimination of SO_2 from stack gases to reduce air pollution creates other problems. One method of removal is the injection of limestone into the combustion flame to form calcium sulphate, but this presents a waste disposal problem; a 1,000 megawatt power plant would produce approximately 1,100 tons of calcium sulfate per day. Other methods that are more expensive in terms of capital investment and operating costs yield sulfur or sulfuric acid as by-products. If these methods are widely adopted, the electric generating industry could produce these chemicals in such large quantities as to damage the existing markets over a relatively short period of time. If our sulfur demand should increase or our resources become limited, then this source might meet sulfur requirements. However, no process now in use is sufficiently economical to encourage general adoption.

TABLE 11

Health Effects of Sulfur Dioxide

Concentration of SO_2 in Air	Effects
25 - 40 ppm	No chronic effects observed
20 - 25 ppm	Irritation
Less than 20 ppm	No chronic effects
.5 ppm	Threshold for odor
.3 ppm	Threshold for taste
5 ppm	Industrial threshold level

More recently, oxides of nitrogen have been recognized as serious atmospheric pollution agents. Nitrogen oxides can be converted in the atmosphere into acids of nitrogen. These nitrogen acids attack much the same materials as the sulfur acids. Nitrogen dioxide produces fading of dyed fabrics and is very poisonous to animals and plants. The effects of nitrogen dioxide on humans are given in Table 12.

Nitrous oxide is of lower toxicity than nitrogen dioxide. However, 50% of nitrous oxide is converted to nitrogen dioxide in a few minutes in the atmosphere. The latter gas retards plant growth at 0.5 ppm. Nitrogen dioxide is produced primarily as a by-product of high temperature combustion. It can be stated that the problem due to nitrogen oxides is primarily one of affluent societies in urban areas. Nitrogen oxides contribute to photochemical smog of urban areas by entering into the reactions which produce PAN, or peroxyacetal nitrate.

TABLE 12

Health Effects of Nitrogen Dioxide

Concentration of NO_2 in Air	Symptoms
Greater than 50 ppm	No tissue response
10 - 40 ppm	Pulmonary fibrosis, Emphysema, and Farmer's Lung
5 - 10 ppm	Irritation of throat and nose
1 - 3 ppm	Odor irritation
5 ppm	Industrial threshold limit

The use of alternate fuels, in addition to posing serious problems for the coal and oil industries, raises other complications. Natural gas, a desirable fuel in terms of sulfur content and other emissions from burning, is limited in supply. It is the least abundant of the fossil fuels, with a potential reserve for only 40 - 60 years.

Currently, an attempt is being made to burn only coal of 0.2% sulfur content in major power plants. At the present time, there is no "economical" means of desulfuring coal; however, fuel oil rather than coal is currently being used by electric utilities.

The movement away from high sulfur content fuels provokes deep concern among coal producers, who see this as a start towards a national policy away from all but the small percentage of coal that contains no sulfur. Such a policy, it has been estimated, will cost the coal industry more than 130 million tons of sales per year.

eliminate 50,000 jobs, and hurt the railroads which profit from a huge coal-hauling business.

The projected rapid growth of the electrical power industry (doubling by 1980), and the unfortunately slower than anticipated growth of the nuclear electric generation of power, are compounding the problem. It is highly unlikely that the 1980 sulfur dioxide emissions will be reduced to even the 1970 levels.

Other proposed alternatives include the gasification of coal, increase in hydroelectric production, geothermal power, tidal power, solar power, use of fuel cells, and increased reliance on nuclear reactions. All of these alternatives at present involve problems. Coal gas, which is relatively pollution-free, costs quite a bit more than solid coal. Fuel cells, because of the cost of their catalysts, are still prohibitively expensive. Costs of catalysts alone now range about $2400 per kilowatt hour of generating capacity as compared with the total costs of approximately $100 per kilowatt hour for steam-powered plants. Nuclear production of energy presents other problems in addition to costs: fear of radiation effects, lack of specific knowledge of the effects of nuclear plant emissions on the surrounding environment, and the acknowledged thermal pollution of rivers, streams, or the atmosphere. Additionally, there is concern over the adequacy of reserves of nuclear fuel. At present, electrical energy utilization amounts to only 0.1% of the total potential energy available in uranium-235. If it were not for the inability to construct and operate nuclear electrical generation plants at maximum capacity, the current supply of $60,000-per-ton uranium ore would become depleted in less than five years. All that would remain is an estimated half million tons at $6 million dollars per ton. Hydroelectric power, now about 12% of installed capacity in the United States, is already approaching full exploitation. Geothermal power, tidal power, and solar power, at present, appear to be limited to specific regions.

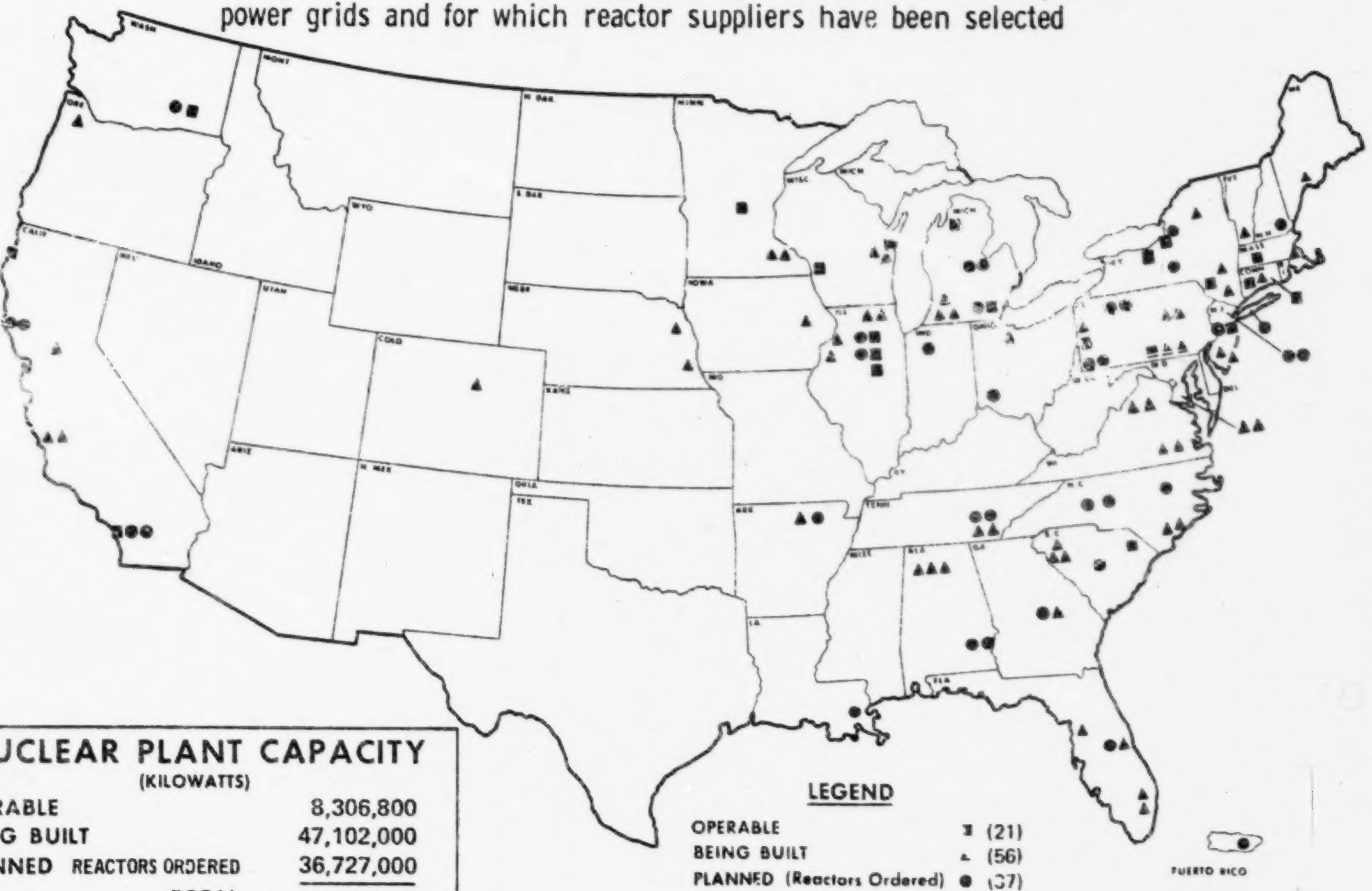
As has been previously indicated, power demands have been nearly doubling every ten years for the last several decades. Projections of this growth rate would indicate an increase in United States power consumption from 1,500 billion kilowatts in 1970, to 2,754 billion kilowatts in 1980. Faced with a shortage of low sulfur fuels, as mentioned previously, and increasing demands, the power industry has been turning increasingly to nuclear-fueled plants. At the time of this writing, July, 1971, there are 21 operable nuclear-fueled power plants producing 8,300,000 kilowatts (see Figure 28). Fifty-six more are under construction, and thirty-seven are in the advanced planning stages with reactors ordered. Minimally, these reactors, planned or operable, should result, by 1978, in 114 nuclear-fueled units producing 92,135,800 kilowatts.

Currently the nuclear-fueled power generators in the United States are of two types, either boiling water, or pressurized water. Figure 29 illustrates the basic components of these systems. In essence, the pressurized water reactor has three discrete water ciscuits for transfer of energy. The first circuitstransfers heat from nuclear fission to a heat exchanger. This heat exchanger transfers heat energy to water in the second circuit at the boiler unit. The steam generated is used to drive a turbogenerator. The third water circuit is usually a through system in which water is drawn from a lake or stream, used to condense the steam, and then returned to the source. It is this third circuit, requiring approximately 1,000,000 gallons of flow per minute in a 1,000 megawatt plant, that is causing concern relative to thermal pollution of streams.

The boiling water reactor uses the steam generated in

NUCLEAR POWER PLANTS IN THE UNITED STATES

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected


WASH
ORE
MONT
IDAHO
WYO
CALIF
NEV
UTAH
COLO
ARIZ
N MEX
N DAK
S DAK
NEBR
KANS
OKLA
TEX
MINN
IOWA
MO
ARK
LA
WISC
ILL
MICH
IND
OHIO
KY
TENN
MISS
ALA
GA
FLA
S C
N C
VA
PA
N Y
N J
MD
VT
N H
ME
MASS
CONN
PUERTO RICO

LEGEND

OPERABLE	■ (21)
BEING BUILT	▲ (56)
PLANNED (Reactors Ordered)	● (37)

NUCLEAR PLANT CAPACITY
(KILOWATTS)

OPERABLE	8,306,800
BEING BUILT	47,102,000
PLANNED REACTORS ORDERED	36,727,000
TOTAL	92,135,800

TOTAL ELECTRIC UTILITY CAPACITY AS OF JANUARY 31, 1971: 340,718,925 KILOWATTS

U.S.Atomic Energy Commission
March 31, 1971

Figure 28

the reactor core to drive the turbine without the intermediate circuit. This system uses water, which has been in direct contact with the reactor in the external system and results in a somewhat higher radioactive discharge into the air.

Radioactive materials inevitably escape into the effluents of nuclear-powered plants. These radioactive materials may result from the escape of fission products in a gaseous form through small holes in the cladding which encase the uranium oxide fuels. Also, gases dissolved in the cooling water may be made radioactive by bombardment with neutrons from the reactor core. Radioactive forms of oxygen and nitrogen have half-lives in the range of seconds and constitute no contamination problem in spite of rather high initial concentrations. Argon-41 has a half-life of 110 minutes. Iodine-131, which escapes in microcurie quantities as a vapor, has a half-life of eight days. Some representative nuclear discharge rates are shown in Table 13.

Regulations currently in effect require that the radiation levels outside the boundaries of the plant be such that the general population is exposed to no more than 0.17 rems per year (a rem is defined as a unit of radiation dosage which is the product of two factors: exposure to ionizing radiation and the relative biological effectiveness of this dosage). Typical background radiation levels from cosmic rays, rock deposits, etc., are in the range from 100 to 125 millirems. Radiation levels within the permitted range are achieved by holding the gaseous effluents until decay has reduced radioactivity to within the safe range. Proposed changes in licensing requirements would reduce the permitted exposure to 5% of the average background exposure, or about 1% of the current Federal protection guide amounts. These new levels are within the effluent range of all

SCHEMATIC OF REACTOR TYPES

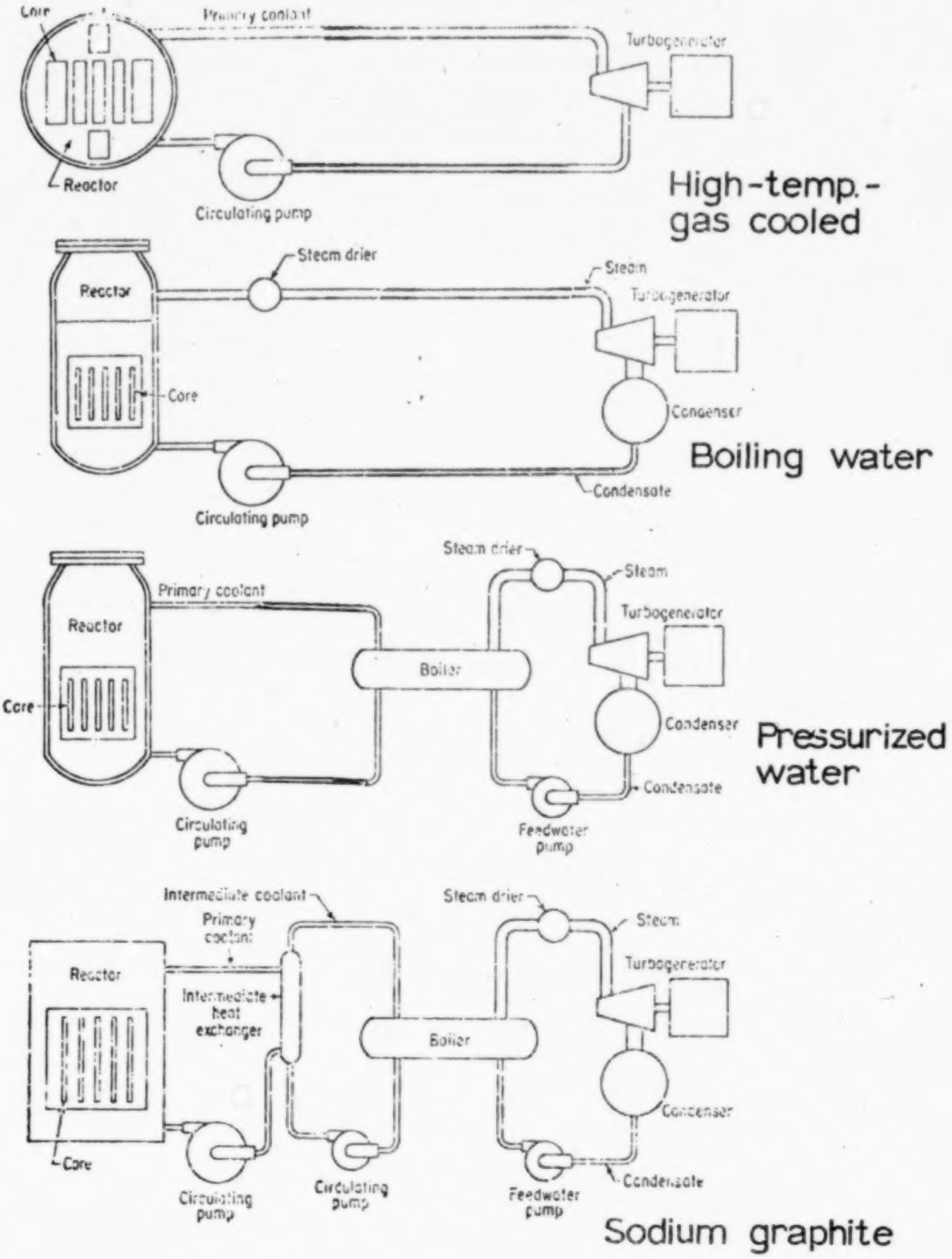

Core
Primary coolant
Turbogenerator
Reactor
Circulating pump
High-temp.-gas cooled
Steam drier
Steam
Reactor
Turbogenerator
Core
Condenser
Circulating pump
Condensate
Boiling water
Steam drier
Steam
Primary coolant
Reactor
Turbogenerator
Boiler
Core
Condenser
Circulating pump
Condensate
Feedwater pump
Pressurized water
Intermediate coolant
Primary coolant
Steam drier
Steam
Reactor
Intermediate heat exchanger
Turbogenerator
Boiler
Condenser
Core
Circulating pump
Circulating pump
Feedwater pump
Condensate
Sodium graphite

Figure 29

but three reacotrs in operation in 1971.

TABLE 13

Nuclear reactor discharge rates of activation and noble gases and of halogens and particulates

Nuclear power plant	Activation and noble gases (uCi/second)	Halogens and particulates (uCi/second)
Dresden I[a]	$< 10^2$ to 2.5×10^4	2×10^{-3} to 3×10^{-3}
Big Rock Point[a]	< 20 to 3.5×10^4	< 1.2
Humboldt Bay[a]	40 to 2.8×10^4	10^{-5} to 7×10^{-2}
Elk River[a]	0 to 1.1×10^2	$< 3 \times 10^{-5}$
Indian Point[b]	0.07 to 1.6	$\sim 2 \times 10^{-8}$

[a] boiling-water reactor   [b] pressurized-water reactor

Utilities complain of the lack of a coordinated and systematic review by a single agency to consider all the factors implicit in the construction of new power facilities (the need for the additional power supply, cost of the project, its impact on the environment, and the available alternatives). Charles F. Luce, Chairman of the board of Consolidated Edison cites the various laws that apply to new construction by Con Ed in a speech before the Bar Association of New York City:

1. If the plant is fossil-fueled, approval is needed from three federal agencies, four New York State agencies, and 20 New York City agencies.
2. If the plant is nuclear, permits must be obtained from the same agencies as for the fossil-fueled plant, and in addition, 2 licenses must be obtained from the U.S. Atomic Energy Commission.

3. If the plant is hydroelectric, a license must be obtained from the Federal Power Commission.
4. If the facility is a new transmission line, right of way through private property must be obtained, in addition to permits from all public bodies whose lands or streets are crossed and from all zoning authorities concerned with the area.
5. If the facility (generating plant or transmission line) is to be located in the Hudson River Valley, plans must be filed with the Hudson River Valley Commission for review to determine whether it conforms to a plan for the preservation, enhancement, and development of the valley. Luce feels that because of this fragmentation of review, "environmental trade-offs, need for power, reliability, cost, relationship to other projects, and alternatives are accorded only such information and ad hoc consideration as men of good will who administer the various laws for protection of the environment feel they can give them."

The increasing shift by power-generating utilities from high sulfur content fuels has meant higher operating expenses for the utilities and consequently, higher prices for electricity. For example, Con Edison of New York has been changing to fuels that contain less than 1% sulfur with the consequence that there will be a decreased use of coal and an increased reliance on gas and atomic power. By 1976, Con Edison will be using low sulfur coal and fuel oil, the equivalent or 6.2 million tons of coal per year, as compared with 10.4 million tons in 1966. New Jersey's Public Service Electric and Gas Company has signed long-termed contracts for low-sulfur oil to replace some coal. In Los Angeles, local rules require utilities to use natural gas instead of fuel oil. Commonwealth Edison in Chicago is retiring its coal-burning units and replacing them with gas turbines and expects, by 1980, to have reduced its use of coal by 68%. Here, too, there is a trend toward atomic power. The increased consumption of low sulfur content fuels in urban areas results in an increase in sulfur content of the fuels available to other geographic areas.

This switch and other measures taken in the interest of pollution control are costing the utilities ever-increasing sums of money. Cincinnati Gas and Electric estimates that its total investment in antipollution equipment runs to nearly $8 million and that expenditures will rise from 3% of total capital investment to 5% and higher in the near future. In addition, removing SO_2 from stacks will increase electric rates by another 5-10% once this equipment is ready for operation, probably in the late 1970's. Their operating costs for pollution control increased from $90,000 a year in 1960 to over $1 million in 1969, largely a result of the change from coal to gas. Con Edison of New York says its fuel costs will rise more than 10% a year, or a total of $15 million. The privately owned electric power industry spent over $200 million in 1969 to counter air pollution as compared with $127 million in 1967. These are all costs that the utilities will pass on to their customers.

For utilities which require fuel with a relatively high sulfur content, there are several processes for cleansing the stack gases that are commercially applicable. These processes are capable of sharply reducing the concentrations of sulfur oxides emitted by electric power generating stations. The consumer will have to pay 6 to 10 percent more for his electricity, according to recent estimates, for these processes.

2. Manufacturing Industries

a. Overview

By their nature, manufacturing industries can be located in a wider range of places than can primary industries. The owner of a coal mine cannot pick up his coal mine and move to another state if he feels the pressure of increased labor cost, or of anti-pollution legislation. In contrast, the manufacturer of a product can, in principle, decentralize his industry in a number of states as it grows. He is governed less rigorously by the location of raw material, and more by such variables as availability of power, cost of labor, business inducements such as low taxes, and advantageous legislation.

Many industries may pollute the environment locally. Some of these industries may have enough plants in many different locations to require federal legislation or sanctions pertaining to the entire industry. This type of legislation, if necessary, should apply wherever the corporate plants are established. Eventually, as concern over world-wide pollution grows, international treaties and agreements will have to be sought so that one country will not, by its manufacturing processes, pollute another.

Since the atmosphere does not respect national boundaries, it would not be acceptable to have a plant, based in an adjacent country, polluting the United States because of prefailing wind. When there are a limited number of plants located in one state, then state-generated emission standards should be sufficient. In fact, a test case is now in progress which will determine if a state can require more stringent controls over an industry than established federal regulations.

Sulfur dioxide is of major concern because of the formation of acid mists which arise from the oxidation and hydration of the original dioxide. Close to 80% of the world's atmospheric sulfur dioxide was originally emitted as hydrogen sulfide. The combustion of fuels accounts for 16% of the world's sulfur dioxide and the smelting of non-ferrous materials and petroleum refining constutute 4% of the total sulfur dioxide which is put into the atmosphere. The industrial contribution of hydrogen sulfide is not significant on a global basis. Natural sources of hydrogen sulfide are organic matter, oceans, and volcanoes.

b. Sources, hazards, and controls

Because of the dependence of our technology on the use of fossil fuels, the petroleum industry is a logical starting point for our examination of air pollution problems in manufacturing industries. There are over 200 refineries of petroleum in the U.S. which supply over 50% of the total United States requirements for liquid petroleum products and natural gas. The petroleum refining process consists of separation, conversion, treating, and blending. We are particularly concerned with the treating process in which sulfur is removed from petroleum as hydrogen sulfide. The hydrogen sulfide is then converted and recovered as sulfur, or it is burned, releasing sulfur dioxide. The industry has spent considerable effort in trying to come up with efficient methods for desulfurization.

Currently, high molecular weight organic molecules are used instead of lead anti-knock additives to achieve non-leaded gasoline. To date, there is no indication whether these additives will result in increased or decreased air pollution when compared to the formerly used lead additives.

More research will have to be done on alternative methods of improving the anti-knock properties of gasoline. Surveys indicate that unleaded gasoline performance levels similar to those of the current leaded fuels can be achieved if the public will accept the 2 to 5 cents per gallon increase.

Refinery emissions cover the entire gamut of major pollutants. The problems vary, delending upon the type of plant and the quantity of emissions. The most effective pollutants are hydrocarbons, nitrogen oxides, sulfur dioxide, carbon monoxides, and smoke. Unsaturated hydrocarbons react rapidly in the atmosphere with oxides of nitrogen and ultraviolet light to produce the various gases which constitute photochemical smog. In 1968, petroleum refineries in the United States vented 100,000 tons of particulate matter, which constituted only 0.4% of the nation's total.

The use of external cyclones can reduce 90% of particulates and a maximum level of control, 98% or more, can be achieved with electrostatic precipitation (see Figure 30). The electrostatic precipitator is most effective in the removal of small particles; however, it will remove gaseous effluent at temperatures below 1100° Farenheit. The particles pass through an ionizing region and are charged by accumulation of ions. Next, these charged particles pass between collecting electrodes. The effluent particles are removed from the electrodes by vibration or washdown.

To achieve 90% control of particulate emissions the investments cost per plant would range between $69,700 and $103,500; for maximum control, the cost would range between $137,000 and $203,000. In order for maximum control to be reached by 1974, total industry investment would have to be between $11.2 million and $16.5 million. Presently in the United States 25% of the plants have achieved maximum

ELECTROSTATIC PRECIPITATOR

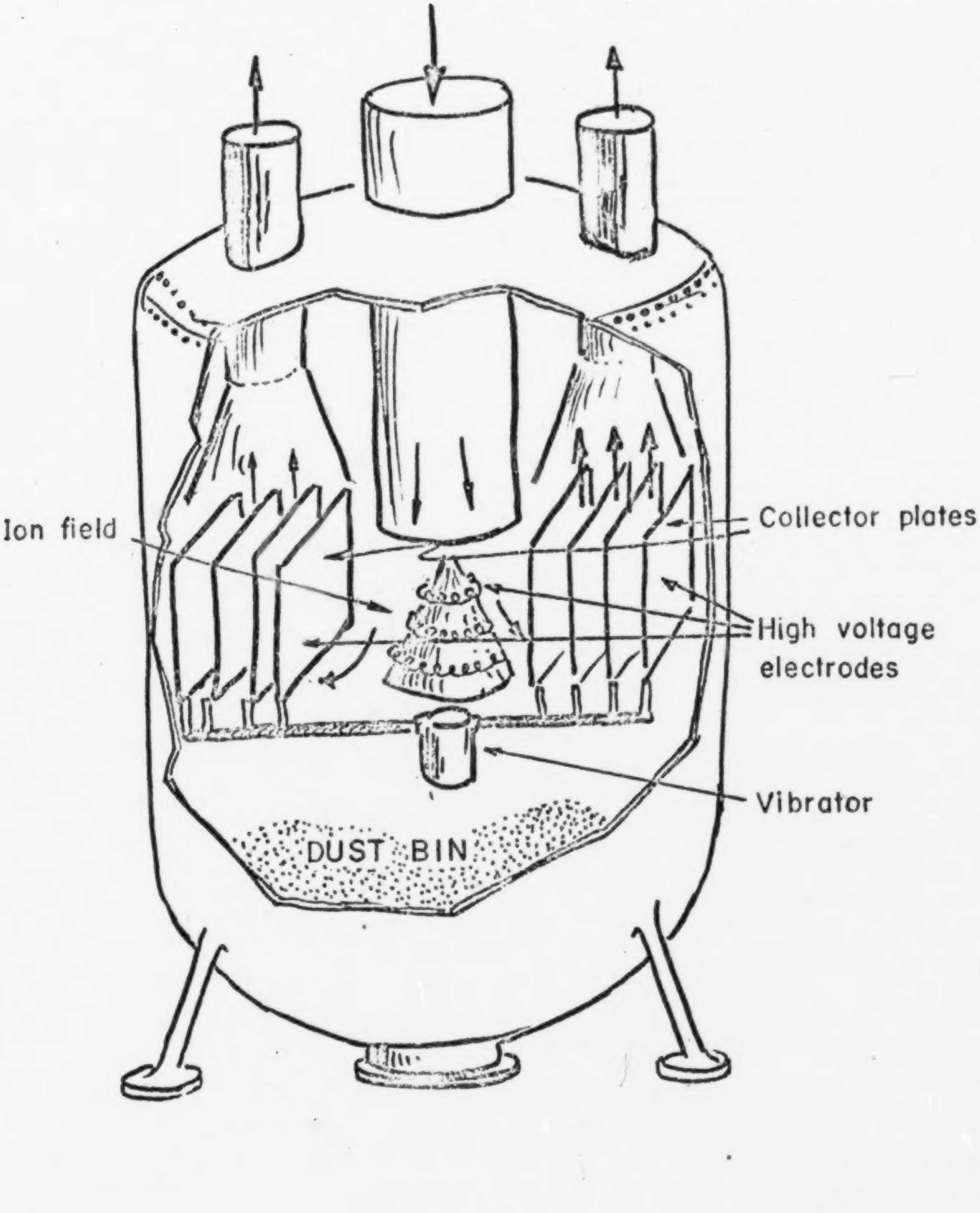

Ion field
Collector plates
High voltage
electrodes
Vibrator
DUST BIN

Figure 30

control, and 75% have none, or only minimum control.

The petroleum industry emitted 2.1 million tons of sulfur oxides in 1966, which was 7% of the national total. The industry's major source of sulfur oxide emissions is the burning of hydrogen sulfide. This gas forms in a number of refinery operations, such as catalytic cracking, hydrocracking, reforming, and hydrotesting. Hydrogen sulfide is also associated with the formation of low-molecular weight hydrocarbon products of paraffin refining. The gas mixture produced, usually called "refinery process" gas, is usually collected and used as a refinery fuel. This hydrogen sulfide can be removed by use of amino absorbers. It can then be recovered to produce elemental sulfur and water vapor.

For the industry to achieve 90% control of sulfur oxides by 1974, estimated costs would be about $18.2 million. In 1966, the petroleum industry spent about $70 million to prevent both air and water pollution. According to a spokesman for Air and Water Conservation of the American Petroleum Instutute: "Produce prices will undoubtedly rise in proportion to the amount of equipment installed and the scope of research and development needed to meet increasingly high standards of air and water purity." (U.S. News and World Report, April 3, 1967, p. 45).

The vast consumption of paper in this country is keeping our pulp and paper mills working overtime. Here, of the three processes, mechanical, semichemical, and chemical, used in the preparation of pulp, the chemical processes have the greatest potential for air pollution. Chemicals used in the preparation of pulp are expensive enough that the plant makes an effort to recover as much of them as possible from the spent cooling liquid. During the chemical recovery process, large quantities of hydrogen sulfide are emitted to the atmosphere. If iron shot is used during the chemical recovery process, iron particles may deposit on painted surfaces in the vicinity of the plant, discoloring the surfaces. These chemical processes also produce offensive, irritating odors. Various systems are in use and proposed for odor abatement in the paper and pulp industry, but the most direct and effective method is incineration, which, unfortunately, does not provide for chemical recovery.

The control of particle emissions in this industry is standard procedure, since the salt cake collected can be used in the paper and pulp process. The use of electrostatic precipitators as a first choice represents high investment and maintenance costs. The second most frequently used collector is the venturi scrubber, which has low investment and maintenance costs.

In order to reach maximum control by 1974, total industry investment would have to be between $2.7 million and $4.6 million. For 18 companies engaged in the production of paper and allied products, 4.51% of the total capital expenditures was spent for pollution controls, of which 1.4% was for air pollution, in 1967-68. During the same period, 14 industries in this field spent a total of $3,150,000 on research and engineering for pollution control.

The Crown-Zellerbach Corporation's Mill at Port Townshed, Washington, has been equipped with new facilities to combat pollution at a cost of $8 million and 2 years for complete installations (including a recovery bioler 10 stories high to remove 98% of solids and 90% of the hydrogen sulfide leaving the plant). Crown-Zellerbach, however, plans to close a Kraft-paper mill in British Columbia because "pollution costs are prohibitive." The St. Regis Paper Company expects to spend $50 million on air and water pollution over the next 5 years. At American

Can Company's new paper mill in Halsey, Oregon, pollution control costs average about 10% of total capital investment.

Presently, sulfate (Kraft) pulpmills account for 2/3 of the total pulp production in the United States. In 1966, sulfate paper mills emitted 315,000 tons of particulates (3.5% of the national total). The major sources of particulate emission are recovery furnaces, generally controlled by electrostatic precipitators, lime kilns, and smelt tanks, both commonly controlled by wet scrubbers.

To control particulate emissions, the cost of investment per plant ranges from \$209,300 - \$336,800 for 80% control, to 352,400 - \$585,100 for 90% control, and \$509,300 - \$851,300 for maximum control.

The American chemical industry today produces nearly half the non-Communist world's supply of chemicals. There is a wide diversity of production. In addition to producing industrial solvents, catalysts, and coatings, the industry provides base ingredients for food, drugs, dyes, fibers, plastics, paints, fertilizers, pesticides, and cleaners. This wide range of products also involves a wide range of waste materials that are introduced into the water and the atmosphere. The speed with which new chemicals are developed, produced, and marketed is often such that there is inadequate knowledge of the long-range effects. Hydrogen sulfides, oxides of sulfur, flourides, organic vapors, acids, particulate matter, and odors are among the wastes added to the air by the chemical industry.

The effect of only one of the chemical industry's effluents--flourides, is well known. Polk County in Florida had been a center of the cattle raising industry since the 1850's and the center of a profitable citrus industry. Between 1953 and 1964, an estimated 150,000 acres of cattle land were abandoned, and 25,000 acres of citrus groves were damaged. In the seven year period between 1953 and 1960, the cattle population of Polk County dropped 30,000 head. The cause of the cattle deaths was diagnosed as flouride poisoning. The source of the poisoning was traced to gas and dust emissions, spread by wind, from the stacks of the many phosphate-processing plants that had appeared in the area following World War II. Powell County, Montana, experienced similar problems with their cattle following the location there of Rocky Mountain Phosphates, Inc., in 1963. Flouride is absorbed and concentrated in vegetation, especially grasses. This can lead to flourosis of animals feeding on the vegetation. Table 14 lists the effects of flourides on human health.

TABLE 14

Flourides and Human Health

Concentrations	Symptoms
120 ppm	-Highest concentration tolerated less than 1 min. by 2mm, smarting of skin.
60 ppm	-Brief exposure - irritation of nasal passages, discomfort of pharynx, trachea.
30 ppm	-All persons complain and object seriously to staying in the environment.
10 ppm	-Experience of discomfort.
3 ppm	-No local immediate effects are noted.
0.1 ppm of flouride	-Threshold limiting value
3 ppm of hydrogen flouride	-Threshold limiting value

There have been a number of lawsuits involving flouride damage. In one case in Florida, the plaintiffs were attempting to force a manufacutrer to install higher stacks. The company argued that this was not a practical solution because the extreme corrosiveness of flouride would corrode the stacks too rapidly. The company won the suit.

In an attempt to alleviate the problems created by the phosphate industry, Florida created the Polk-Hillsborough Air-Pollution Control District. At a cost of $16 million to the phosphate industry between 1959 and 1965, flouride emissions were cut from 33,000 pounds per day in the winter of 1961-62, to 13,000 pounds per day in the winter of 1963-64. Actually, the cost of this control has been higher than the figures indicate because it has meant the building of more modern plants, one, for example, at a cost of $20 million. Even with these measures, the continued existence of the problem will require more stringent control which will in turn mean higher expenditures. Due to this, one large company closed its phosphate subsidiary because it felt that changes in treatment were not economically feasible.

The largest group of activities under the inorganic chemical industry label is the productions of acids. The greatest hazard created by this process is the release of acid mists which can cause the deterioration of materials in the near vicinity of the plant. A colorless effluent cannot be accepted as an indication of proper plant operation. The emissions from a nitric acid plant can be made colorless by reaction with methane; however, the corrosive properties are not eliminated.

Costs to the chemical industry for pollution control have increased in recent years. A report issued by the Manufacturing Chemists Association surveyed the recent activities of chemical manufacturers in controlling pollution. The report indicated that by the beginning of 1967, the U.S. Chemical Industry had invested $673 million in air and water pollution control facilities and had spent $226 million, or about 40% of this investment, in the five year period 1962-66. Based on these figures, the MCA has projected that the chemical industry will invest $405 million during the period 1967-71. To operate and maintain these facilities, annual expenditures by the industry had reached $101 million at the beginning of 1967, showing a 50% increase over the previous five year period. Operating expenditures for air pollution control were $23.7 million in 1962, and $41.7 million in 1967. In the area of research for air pollution control, spending by the industry was $9.1 million in 1967.

The increasing amounts spent by the chemical industries in the area of pollution control have produced several changes within the industry. For example, a spokesman for Union Carbide says: "In our processing work with chemicals and plastics, we used to concern ourselves with minimum investment and efficiencies of raw materials. Now we have a third ingredient, pollution costs. So we reassess the process. We trade off the original reactants for more expensive ones if the process results in fewer pollution costs." (Business Week, April 11, 1970, p. 66).

As a consequence of tackling their own pollution problems, several chemical companies are using their knowledge thus gained to enter the pollution control business. Monsanto has combined all of its pollution control activities into Environmental Control Enterprise. Included in this will be Monsanto's subsidiary, Biodize Systems Inc., which offers commercially the Cat-Ox catalytic oxidation process systems for removing SO_2 from stack gases. American Cyanamid, Allied Chemicals, Dow Chemical, DuPont, and Union Carbide are other companies that are in the business of pollution control.

Ores of the non-ferrous metals: copper, lead, and zinc, occur as sulfide minerals in the earth's crust. The smelting of the ores results in the removal of sulfur as sulfur dioxide. Additionally, the emissions of flourides from aluminum smelting are of great concern. But possibly of more concern is the rapid increase of new products and the improvement of existing products for our societal needs, which leads to the utilization of new metals that contribute to atmospheric pollutants. In most instances, little research and testing have been done relative to their potential as atmospheric pollutants before their use by industry. In this section we shall cite existing evidence concerning the dangers that arise from the production and process of various non-ferrous metals.

Arsenic, which has been used for many years as an insecticide, is emitted primarily during the nickel, cadmium, zinc, and copper smelting operations. Small amounts of arsenic can be measured in the ambient air of most cities. The effect of arsenic and its compounds on humans is dependent upon the level of concentration and the particular compound, i.e., elemental arsenic is non-toxic, but arsine (AsH_3) is extremely toxic. Humans can take in arsenic compounds by inhalation, ingestion, or absorption through the skin. Currently, the supply of arsenic produced by smelting operations is greater than the commercial demand. The disposal of large stockpiles is an ongoing problem.

There have been three arsenic poisoning episodes in 1903, 1905, and 1962 associated with smelting operations. The local population showed the effects of arsenic poisoning while herbivorous animals died during the incidents, and in one instance, the Montana episode, animals were killed as far away as 15 miles from the plant.

Very little is known about the dangers of barium. This element is being studied currently as a potential air pollutant because of its extensive use in diesel fuels as an additive for reducing black smoke emissions. Barium compounds are also used in the oil drilling industry, in the white paint pigment: Lithopone, and in paper, rubber, cloth, linoleum, and oil cloth as a filler. The only evidence of an effect upon humans is the production of a benign pneumonicosis (known as baritosis), in persons inhaling barium compounds. Soluble barium compounds are known to be highly toxic.

Beryllium is among the most toxic and hazardous of the substances being used in industry. One of its original uses was as a phosphor in flourescent lamps. This use continued until 1949. The primary sources of beryllium pollution are mining, burning of coal, and exhausts of machine shops and foundaries.

Boron is probably inhaled as a dust during the production and manufacutre of boron compounds and products. Borates are used in high-energy fuels and produce a localized problem where these fuels are used. Borate poisoning is characterized by disorders of the central nervous system.

Cadmium occurs as a by-product in the refining of zinc and other metals. It has a large range of industrial uses (e.g., electroplating, storage batteries, semiconductors, atomic fission controls, fertilizers, and pigments for paints). Cadmium can produce chronic and acute poisoning. Inhalation of cadmium fumes causes damage to the kidneys and studies have linked it to heart disease and cancer. Recently, the first report of cadmium poisoning of a Japanese female worker in the electronics industry was published. In this instance, the cadmium was reported to have replaced skeletal calcium, which led to extreme pain and a weakening of bodily functions. The worker died by committing suicide.

The decorative use of chromium as well as the production of stainless and austenite steel, and chromium chemicals (fuel additives, corrosion inhibitors, pigments, and tanning agents) has increased environmental contamination. It has been found that a number of health problems arise from contact with the compounds of chromium: ulcers on the skin, perforation of the nasal septum, and cancer of the respiratory tract. It is both stimulating and toxic to plant growth, depending upon the concentration applied to the plant. Contact will cause corrosion of metals, discoloration of paints and building materials, and damages to paper and textiles.

Almost all manganese enters the atmosphere as manganese oxides, primarily from blast furnaces. Other sources include the manganese found in fuel additives, welding rods, and the incineration of manganese-containing products. As a pollutant, manganese acts as a catalyst, producing even more undesirable atmospheric pollutants, e.g., sulfur trioxide. Manganese can cause generalized soiling of materials, as well as manganese poisoning (a disease of the central nervous system), or manganic pneumonia in humans.

Mercury is used extensively for the electrolytic preparation of chlorine and caustic soda. Also, mercury is used in increasingly greater amounts in electrical apparatus, apints, and laboratory products. This increased use results in potentially hazardous conditions in laboratories, schools, hospitals, and dental offices. Both mining and teh refining of ore lead to the input of mercury and its compounds into the atmosphere.

Mercury can lead to the poisoning of the human system. Atmospheric monitoring of this substance should increase in the future. Once the mercury passes the blood-brain barrier, it becomes bound in the brain in greater concentrations than any other organ of the body. Alkyl mercury compounds affect the motor and sensory nerves, and this disorder is known as chronic poisoning. When acute toxicity occurs, the following symptoms may be noted: metallic taste, nausea, vomiting, diarrhea, and headache. Teeth may loosen and ulcers may develop on the lips and cheeks.

The predominant use of nickel ore in the production of stainless steel and nickel-plating, along with the use of nickel for the aging of liquors, dying of oils, bleaching, purification of waste water, cracking of ammonia, and catalytic combustion of organic compounds in auto exhaust. While nickel metal is non-toxic, the nickel salts are highly toxic. The inhalation of the nickel compounds may produce cancer of the lung and sinus, or other respiratory diseases. Signs of central nervous system disorders are quite common. Nickel carbonyl, which is found in cigarettes, is known to be extremely toxic.

Selenium dust, fumes, or vapor, produces irritation of eyes, nose, throat, and respiratory tract on contact. A prolonged exposure results in gastrointestinal disorder, and possibly kidney and liver damage. An early indication of a selenium disorder is a garlic odor of the breath. Selenium is produced as an atmospheric pollutant at copper refineries and lead smelters. It is used in the production of electronic and electrical products, paint pigments, glass, lubricants, blasting caps, photocopies, stainless steel, and chromium plating.

The present concentrations of vanadium found in the atmosphere are very low. The increased use of vanadium, and the consumption of vanadium-bearing oils and coals will increase the potential for air pollution by vanadium. New York and New Jersey rank first and second, respectively, with regard to vanadium concentration in the ambient air, but this is probably due to the high density of vanadium chemical industries found in these states. The uses of vanadium are in photography, ceramics, atomic reactors, and as a catalyst, for example, in the production of sulfuric acid by the contact process.

At present, only threshold limit values have been set for these metals and their compounds by the governmental industrial hygienists. To date, no environmental air pollution levels have been set for these various metals or their compounds.

The open-hearth method of steel manufacture which produces 7-12 pounds of dust and fume per ton of produced steel is being replaced by the oxygen furnace. The electric arc furnace presents special problems in emission control because of the location of the electrodes and high temperatures involved. The major pollutant is iron particulate which can coat all surfaces in the neighborhood, thus depreciating the value of property. Iron oxide is not considered to be toxic, but it is considered a nuisance pollutant. However, to the car owner who must repaint his car or the parking lot owner who must close the lot because of its proximity to a steel-producing plant, iron particulates are more than a nuisance. The steel plant may find that upon controlling pollutants, they cannot dispose of them in adjacent water supplies and unless they own considerable land; the disposal of iron oxide in approved landfill locations might be quite costly. The steel industry might well find itself involved in the trucking business.

In 1968, the steel industry's emission of particulates amounted to 1,900,000 tons, or 7.0% of the national total. The industry also emitted about 415,000 tons of sulfur oxides, although fuels burned in the process portion of steel industry are already below 1% sulfur content for metallurgical reasons. The blast furnaces used to reduce iron ore to pig iron are not a significant source of air pollution, since the exhaust gases are normally cleaned to a high degree and recycled to be consumed as fuel. The particulate emissions in steel production come from sinter plants, open-hearth furnaces, basic oxygen furnaces, and electric furnaces.

The highest estimate of the annual cost of maximum control for particulate emissions in 1974 is $69.7 million. This would be less than one half of one percent of the projected value of the product for that year. The investment to control emissions from an open-hearth furnace ranges from a low of $90,000 per plant for 80% control, to a high of $285,000 for maximum control. For a basic oxygen furnace, control costs range from a low of $337,500 for 80% control, to a high of $1,068,800 for maximum control. Costs for an electric furnace range from $72,000 for 80% control, to a high of $228,000 for maximum control. Sintering plant costs range from $169,300 for 80% control, to $1,262,700 for maximum control.

The total steel industry investment to reach 80% control by 1974 would range between $33,500,000 and $67,500,000; to reach 90% by 1974, between $33,900,000 and $68,000,000; and to reach maximum control by 1974, between $63,900,000 and $126,900,000.

In the Calumet area, Chicago-Gary, Indiana, the four major steel producers in the area have agreed to spend $50 million by 1972, substantially reducing their air pollution. These four producers account for 90% of Chicago's steel production. Youngstown Sheet and Tube Company is installing a water control plant to eliminate discharges of flue dust from blast furnaces at a cost of $2.5 million. Interlake Steel Corporation has spent $1.5 million to date for electrostatic precipitators. In New York State, approximately $1.00 per ton of the cost of steel is accounted for by air pollution control costs. New York State's portion of the iron and steel industry's investment in control and abatement equipment is expected to double by 1973, going from $17.9 million in 1967, to $40.7 million in 1973. If operating costs/air pollution control costs remain in the same ratio, then in New York State, the steel industry would spend around $10 million by 1973 for abatement.

U.S. Steel, which has been using electrostatic precipitators since the early 1950's puts its cumulative investment in air and water pollution controls at well over $235 million in 1969. Bethlehem Steel figures that its expenditures for pollution control will rise from 6% to 11% of its capital investment. The American Iron and Steel Institute estimates that reporting members are currently budgeting over $325 million a year for pollution control of one kind or another.

Even as U.S. Steel and others are installing new controls, a "Big Steel" spokesman has said that there is no chance, at least for the present, of changing internal processes to eliminate a major pollutant - iron dust. Abatement efforts are being concentrated at points of emission and for a good economic reason: The basic oxygen furnace, a very heavy polluter, is still the most economical way to produce large quantities of steel.

The minor fabrication industries may contribute substantially to the pollution of the local environment. An asphaltic concrete plant produces both dust and odor. The odor is usually a very localized problem and the particulate emission can be reduced twenty times with appropriate control devices. Concrete batching plants produce local dust problems which can be controlled. An uncontrolled plant is estimated to produce ten times the dust as to a controlled plant. The production of cement is a notorious dust source. The cement dust settling on materials in the neighborhood quickly produces a hard, gray coating which can only be removed by using extreme measures. A large cement plant may produce as much as 60 tons of dust per day. Even if this amount were reduced by 95%, the resulting 3 tons of dust per day would result in an air pollution problem no matter where the plant is located. Because of the tremendous amounts of dust produced, the collector used must be 99% + efficient. Yet, because of the concentration of plants near the natural resources, even the use of the most efficient filters may not be enough; dustfall rates of over 35 tons per square mile per month are being recorded in areas of the Lehigh Valley in Pennsylvania. This amount can be compared to the very heavy dustfall of New York City, New York, of approximately 100 tons per square mile per month.

In 1966 there were 188 cement plants in operation in the U.S. Of these, 116 were wet process plants and the remainder were dry process. Both processes are potential sources of substantial amounts of particulate emissions. In 1968, Portland Cement, with 98% of the total cement production, accounted for about 870,000 tons of particulate emissions, 3% of the national total.

In cement production, the main source of emissions is the kiln. Other sources include grinding and materials handling operations, but air pollution control is an integral part of these operations as the value of recovered products is more than enough to pay for the cost of control.

The investment cost per plant for particulate control ranges from a low of $47,300 for 80% control in a wet plant, to a high of $405,000 for maximum control in a dry plant. Total industry investment to reach maximum control by 1974 would range from a low of $15.2 million to a high of $17.4 million.

Asphalt batching plants are sources of potentially heavy dust emissions; many plants emit well over 1000 pounds per hour. Even with an industry-wide average level of 90% control, asphalt plants account for about 540,000 tons per year of particulate matter, or about 2.0% of the nation's total. Within each plant, the rotary dryer is the principle source of particulate emissions.

Based on 1974 capacity of asphalt batching plants, the high annual cost for maximum particulate reduction is $19.8 million. This would be about 1.17% of the projected value of shipments for that year.

The production of glass and ceramics requires very high temperatures (1000-17,000°C) which convert part of the raw materials into gaseous mixtures. The principle gaseous pollutant, hydrogen chloride, is found to be a constituent of some furnaces with a downwind concentration approaching 1 ppm. This causes attendant material and vegetative damage in the adjacent area.

The milling, product manufacturing, and use of asbestos has become of prime importance lately. The asbestos fibers are placed into the air through milling procedures, deterioration of automotive brake linings, and, more recently, the use of sprayed-on fibers as insulation in the building construction trade. The fiber can reach a human lung where it may cause asbestosis. This disease has been recognized since 1927 as being associated with the mining and processing of asbestos. The lung lesion is a diffuse fibrous infiltration. Coughing, loss of appetite, and increased shortness of breath are symptomatic of the disease. It has also been linked with lung cancer. Unfortunately, the disorder does not become apparent until 15-30 years after exposure to asbestos fibers.

D. Transportation

Societies have always had a need for transportation. Individual and socio-economic criteria for transportation include freedom, mobility, rapidity, and convenience. These are the primary considerations in the development of any transportation system. The automobile provides us with optimum speed, comfort and flexibility between origin and destination. Our changing social patterns have necessitated not single, but multiple vehicular transportation per family. The wife now works, or must transport the children. House calls by doctors and deliveries by stores are on the decrease. Weekend road trips are formulated and promoted by travel and state agencies.

The most vigorous efforts to control air pollution will need to be aimed at the largest single source, transportation, which produces greater than 45% of the total emitted atmospheric pollutants. It is in precisely this area that perhaps the greatest obstacles are encountered. It is much easier to regulate one stationary source than 10,000 automobiles (there are approximately 100 million automobiles in the United States). Furthermore, no one legislative agency has control over the transportation industry.

The exhaust emissions from the automobile are most important. Sixty-three percent of the total carbon monoxide emitted annually comes from gasoline-powered motor vehicles. Even though vehicular travel is evenly divided between urban and rural areas, the slower driving speeds which prevail in urban areas accounts for well over 60% of the total carbon monoxide emissions. Adding to the carbon monoxide problem are the emissions from refuse disposal, aircraft below 30,000 feet, and industrial emissions in urban areas. Table 15 shows the nationwide carbon monoxide emissions for 1968 by category. Carbon monoxide is chemically relatively inactive, but it restricts oxygen intake severely (see Table 16). High concentrations during peak traffic, are found at street level, and in tunnels. It has been conjectured that many automobile accidents in tunnels are the result of an impaired judgment produced by increased carbon monoxide levels in the blood stream.

Hydrocarbon emission is next in importance and nitrogen oxides are third. Motor vehicles accounted for over 50 percent of the total hydrocarbons emitted in the United States. One half of the hydrocarbon emission occurred in urban areas with the production of hydrocarbons inversely related to speed. A marked decrease in hydrocarbon production will occur in rural areas where travel speeds are higher and stops are minimized. Table 17 summarizes hydrocarbon sources.

The burning of fossil fuels accounted for 88 percent of the total emitted nitrogen oxides in the United States in 1968. Within this 88%, 8.1 million tons came from transportation, of which 7.2 million were accounted for by motor vehicles (see Table 18). Unlike carbon monoxide and hydrocarbons, nitrogen oxide emissions are unaffected by the speed of the vehicle. It is not surprising that the movement of population to metropolitan areas correlated with the 60 percent of all nitrogen oxides occurring in urban areas.

The exhaust gas from automobiles accounts for all of the carbon monoxide, nitrogen oxides, lead compounds, and 65 percent of the hydrocarbons. The remaining hydrocarbons are emitted from the crankcase and evaporation from the carburetor and fuel tank. On a hot day in congested traffic the emission of hydrocarbons from the

TABLE 15. NATIONWIDE CARBON MONOXIDE EMISSIONS, 1968

Source	Emissions, 10^6 tons/yr	Percent of total
Transportation	63.8	63.8
Motor vehicles	59.2	59.2
Gasoline	59.0	59.0
Diesel	0.2	0.2
Aircraft	2.4	2.4
Railroads	0.1	0.1
Vessels	0.3	0.3
Non-highway use of motor fuels	1.8	1.8
Fuel combustion in stationary sources	1.9	1.9
Coal	0.8	0.8
Fuel oil	0.1	0.1
Natural gas	N[a]	N
Wood	1.0	1.0
Industrial processes	9.7	9.6
Solid waste disposal	7.8	7.8
Miscellaneous	16.9	16.9
Forest fires	7.2	7.2
Structural fires	0.2	0.2
Coal refuse burning	1.2	1.2
Agricultural burning	8.3	8.3
Total	100.1	100.0

[a] N = Negligible

Source - NAPCA Publication # AP-73

TABLE 16. HEALTH EFFECTS OF CARBON MONOXIDE (CO)
Prepared by D.M. Snoodderly, Jr., New York Scientists' Committee for Public Information

Concentration of CO in Air	% Carbomonoxyhemoglobin in blood	Symptoms
Up to 300-400 ppm	30-40% and above	Severe headache, dim vision, nausea, collapse.
100 ppm	Up to 20% depending on exposure and activity of subject.	Headache at 20%. Impaired performance on simple psychological tests and arithmetic above 10% CO in blood.
	20% in dogs exposed for only 5.75 hours per day, for 11 weeks.	Brain and heart damage found at autopsy.
50 ppm and below	2 - 4% and above. Maximum of about 8% (calculated from 5)	Ability to detect a flashing light against dim background worsens with increasing amounts of CO. 4% was lowest point shown, but authors state that even the CO from a single cigarette could be shown to cause rise in visual threshold. It it, therefore, obvious that smoking and exposure to CO from auto exhaust interact. Subjects presented with two tones and asked to judge which is longer. Judgment impaired at this level of CO in the air; lower levels of CO not studied. Results interpreted as impairment of ability to judge time. Not known whether this may influence people's ability to judge time. Not known whether this may influence people's ability to drive safely. Another author concluded that 1 - 2% CO in the blood should cause a detectable number of errors on psychological tests if a sufficiently large-scale experiment were done.
15 ppm	Up to 2.4% (calculated from 5)	New York's air quality goal. Even this amount of CO could cause some of the effects on vision and loss of judgment of time that are mentioned above.

TABLE 17. NATIONWIDE HYDROCARBON EMISSIONS, 1968

Source	Emissions, 10^6 tons/yr	Percent of total
Transportation	16.6	51.9
Motor vehicles	15.6	48.8
Gasoline	15.2	47.5
Diesel	0.4	1.3
Aircraft	0.3	0.9
Railroads	0.3	0.9
Vessels	0.1	0.3
Non-highway use of motor fuels	0.3	1.0
Fuel combustion in stationary sources	0.7	2.2
Coal	0.2	0.6
Fuel oil	0.1	0.3
Natural gas	N[a]	N
Wood	0.4	1.3
Industrial processes	4.6	14.4
Solid waste disposal	1.6	5.0
Miscellaneous	8.5	26.5
Forest fires	2.2	6.9
Structural fires	0.1	0.3
Coal refuse burning	0.2	0.6
Agricultural burning	1.7	5.3
Organic solvent evaporation	3.1	9.7
Gasoline marketing	1.2	3.7
Total	32.0	100.0

Source: NAPCA Publication # AP-73

TABLE 18. NATIONWIDE NITROGEN OXIDES EMISSIONS, 1968

Source	Emissions, 10^6 tons/yr	Percent of total
Transportation	8.1	39.3
Motor vehicles	7.2	34.9
Gasoline	6.6	32.0
Diesel	0.6	2.9
Aircraft	N[a]	N
Railroads	0.4	1.9
Vessels	0.2	1.0
Non-highway use of motor fuels	0.3	1.5
Fuel combustion in stationary sources	10.0	48.5
Coal	4.0	19.4
Fuel oil	1.0	4.8
Natural gas	4.8	23.3
Wood	0.2	1.0
Industrial processes	0.2	1.0
Solid waste disposal	0.6	2.9
Miscellaneous	1.7	8.3
Forest fires	1.2	5.8
Structural fires	N	N
Coal refuse burning	0.2	1.0
Agricultural burning	0.3	1.5
Total	20.6	100.0

Source: NAPCA Publication # AP-73

carburetor and fuel tank approximates that from the tail pipe.

The 1963 crankcase control device (see Figure 34) decelerated the rate of increase of hydrocarbons. Except for aromatics and ethylene, unburned hydrocarbons pose no great problem in the atmosphere. However, it is the photocatalytic chemical process resulting in the production of oxidant which makes the hydrocarbons undesirable. In order to control carbon monoxide and unburned hydrocarbon emissions, the techniques of better fuel control, adjustments to spark timing, containment of crankcase, fuel tank and carburetor vapors, along with mechanical changes, have been tried. The exhaust may be converted by catalytic muffers (see Figure 34) or by being converted when kept sufficiently hot and exposed to oxygen. In addition to this device, evaporation control is obligatory for 1970 model cars. Figure 31 shows clearly that if automobile exhausts are not controlled by 1975, the automobile would account for almost one half of the total world pollution generation. By controlling the emissions of automobile exhaust, it is projected that by 1990 the automobile and aircraft would produce about 40% of the world pollution generation from the consumption of fossil fuels.

The engine emission comparison (Figure 32) points out that the turbine engine would be the most feasible method at this time to decrease pollutants at cruising speeds. In urban areas, society must shift quickly to some type of rapid mass transit or electrical-powered vehicle to transport people. The diagrammatic analysis of pollutants found in Figure 38 demonstrates that the combustion process at high temperatures will produce a variety of pollutants. This burning is not enough to produce the expected by-products of complete combustion -- carbon dioxide and water vapor.

PROJECTED LEVELS OF WORLD ATMOSPHERIC POLLUTION

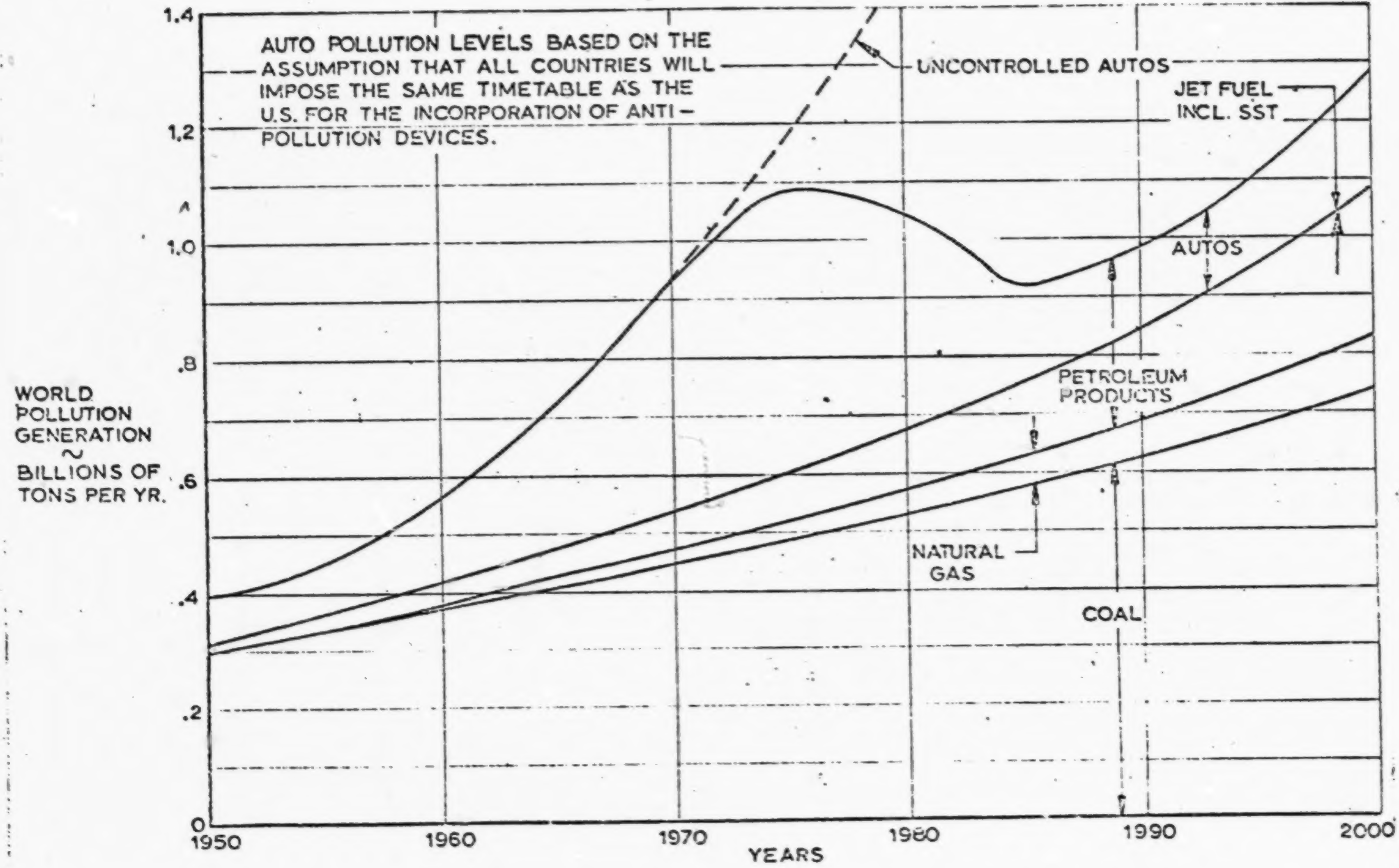


FIGURE 31 PROJECTED LEVELS OF TOXIC POLLUTANTS IN THE WORLD ATMOSPHERE

ENGINE EMISSION COMPARISON

AT CRUISE POWER

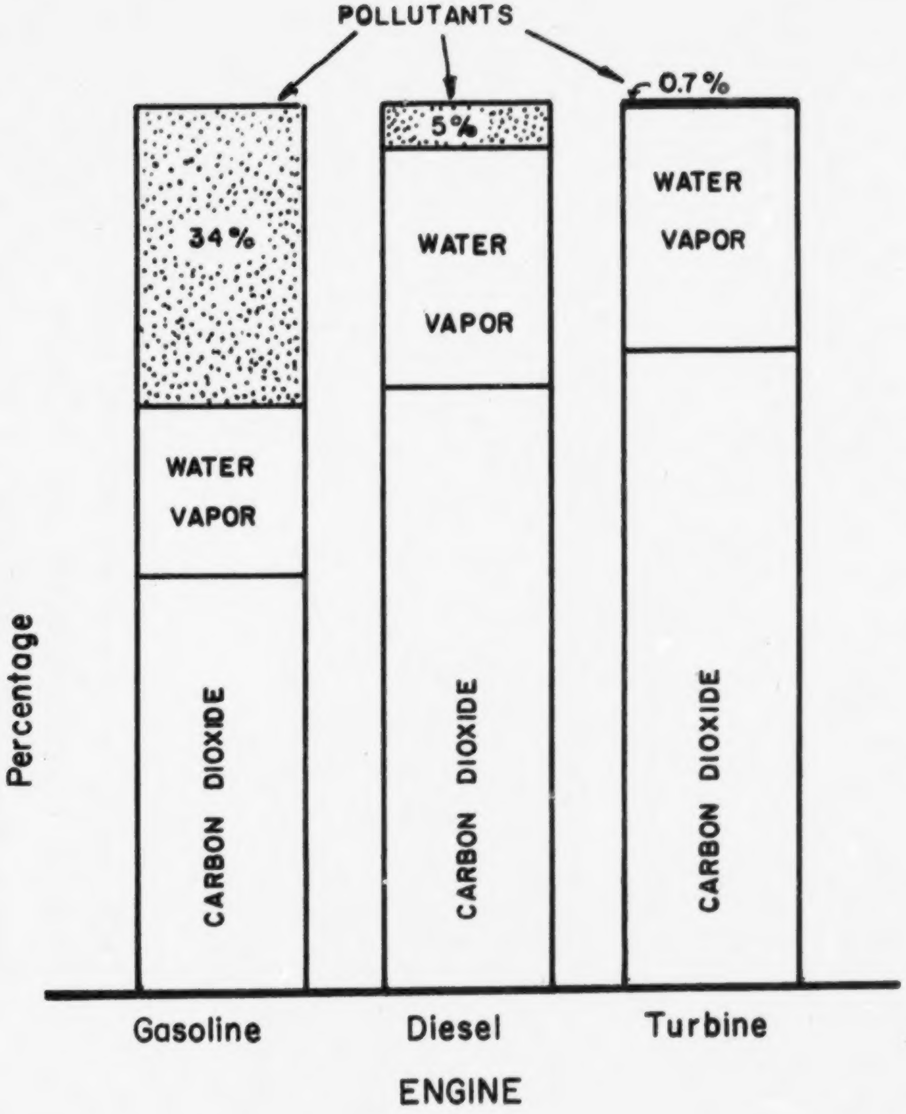
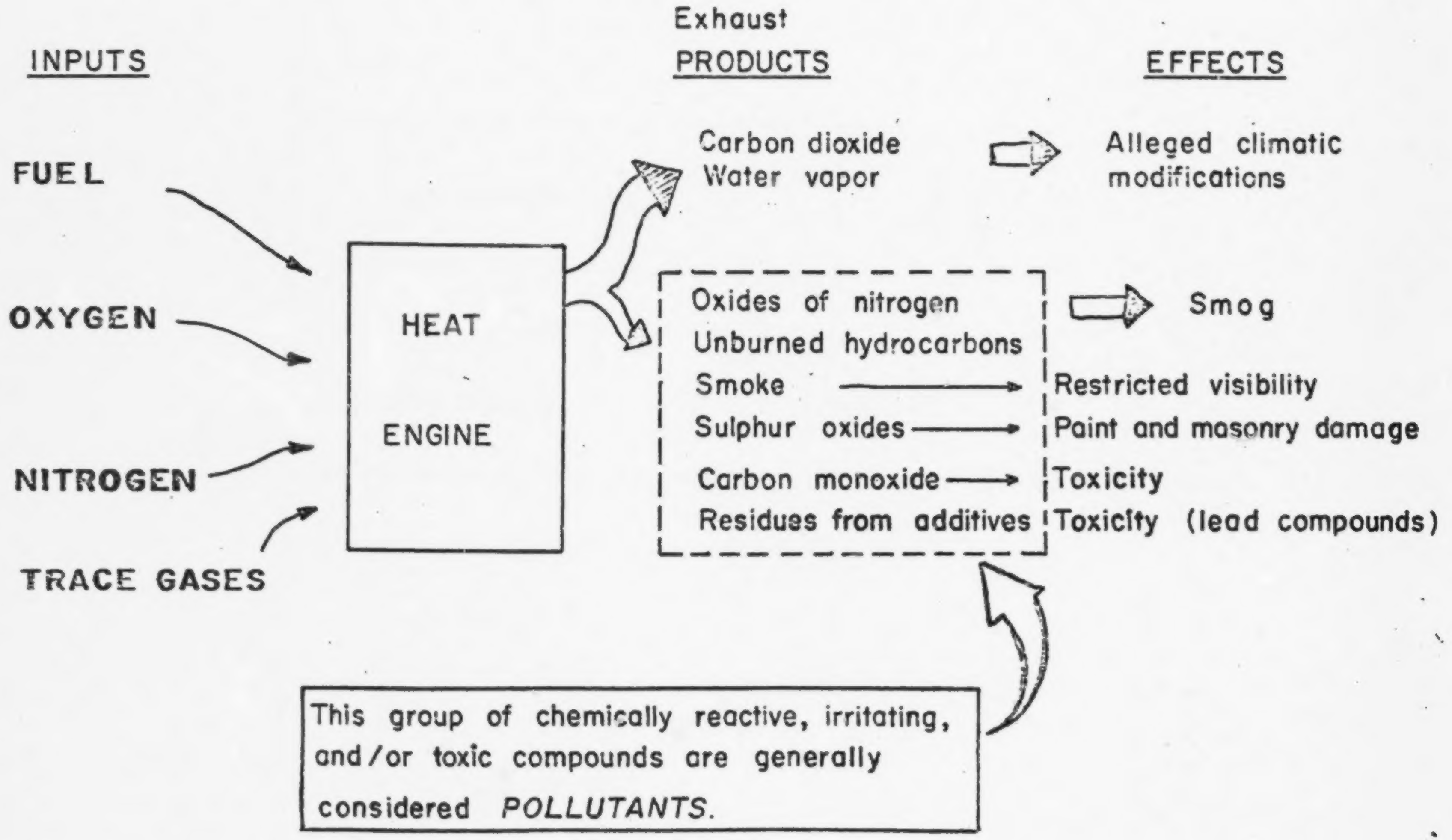


Figure 32

AIR POLLUTANTS


INPUTS
FUEL
OXYGEN
NITROGEN
TRACE GASES
HEAT
ENGINE
Exhaust
PRODUCTS
EFFECTS
Carbon dioxide
Water vapor
Alleged climatic modifications
Oxides of nitrogen
Unburned hydrocarbons
Smog
Smoke
Restricted visibility
Sulphur oxides
Paint and masonry damage
Carbon monoxide
Toxicity
Residues from additives
Toxicity (lead compounds)

This group of chemically reactive, irritating, and/or toxic compounds are generally considered *POLLUTANTS*.

Figure 33

INTERNAL COMBUSTION ENGINE
(Modified)

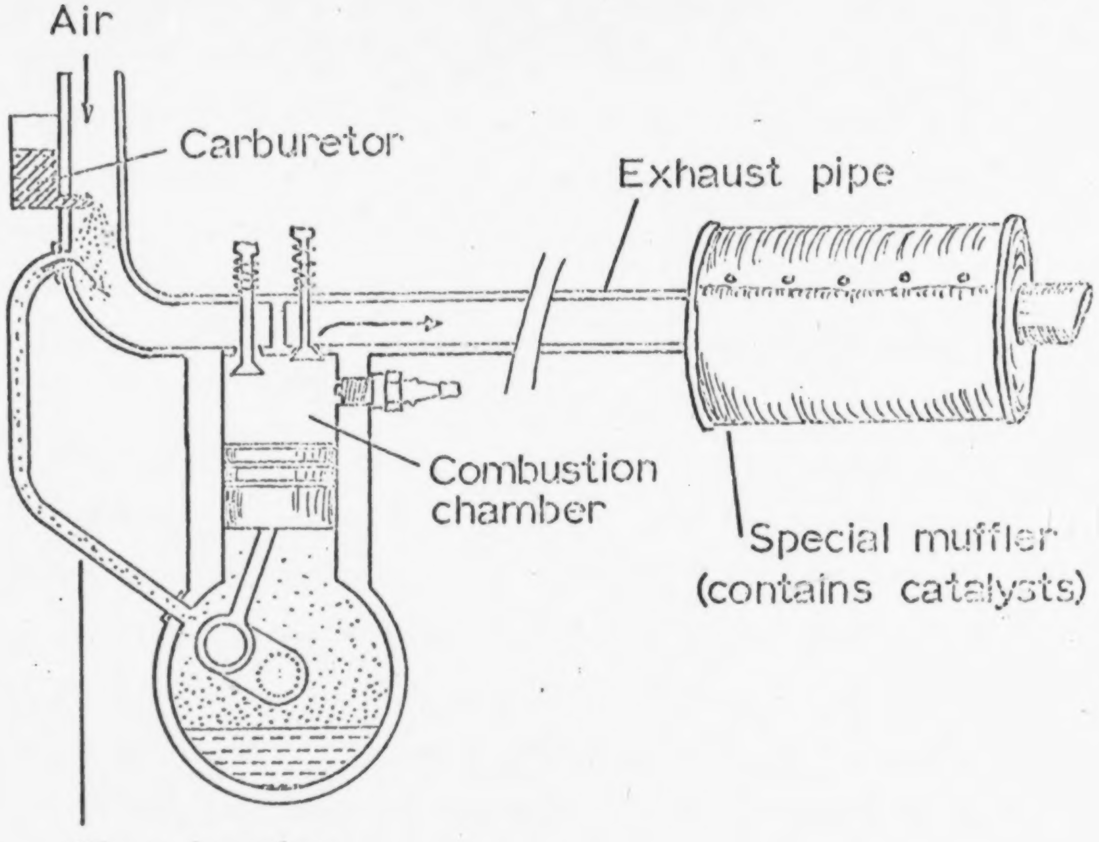

Air
Carburetor
Exhaust pipe
Combustion chamber
Special muffler
(contains catalysts)
Blow-by pipe

Figure 34

The most feasible method to control nitrogen oxide emission is by restricting its production in the combustion chamber. This would require modifying the combustion temperature by such adjustments as retarding the spark, burning a richer mixture, or lowering the compression ratio. The recycling of exhaust gas will also accomplish the reduction of nitrogen oxides by reducing the total oxygen in the combustion chamber. In this technique about 25% of the exhaust gas is reintroduced into the intake manifold. Engine adjustments which reduce carbon monoxide and hydrocarbons by burning higher oxygen-to-fuel mixture conversely results in increased nitric oxide production. Since there are no current effective controls for nitrogen oxides, these emissions will continue to increase at the same rate as vehicular travel.

Currently, new cars are built at the rate of 22,000 per day and it is predicted that production will climb in the near future to 41,000 per day. The Automobile Association of America expects that by 1985 there will be 170 million cars - 60% more than there are today. Put in other terms, the human population of the United States is expected to grow by 58 million by the end of this decade, while in the same time span, the car population will grow by 50 million. By the end of the seventies, metropolitan traffic volumes are expected to increase (Some examples: 40% increase in Pittsburgh, 50% in Boston, 90% in Detroit, and 100% in Los Angeles). Current projections indicate that by 1980-1983 the increase in motor vehicle travel will counter-act the effects of the controls if the internal combustion engine is still in use.

Federal statutes requiring the installation of pollution control devices on new cars only bind the manufacturer; there is no federal requirement, as yet, that binds the individual car owner to maintain these devices once installed. Some states, like New York, New Jersey, and California, for example, do have laws that require the maintenance of these controls; however, at this writing, there are no effective, simple procedures for testing and maintenance. There are as yet no laws compelling the installation of these controls on older model cars, and it is estimated that it takes from 5-10 years for the national car population to be renewed.

The estimated cost to the consumer for the installation of the various federally required pollution controls is: $18 per car to meet the 1968 standards, $36 per car to meet the 1970 standards, and $48 per car to meet the 1971 standards. These figures are industry estimates of the costs that have been or will be passed on to new car buyers.

A large part of the problem of cars and their concomitant pollution is the amazing degree to which the automobile has become such a part of the fabric of American life. Two nationwide surveys conducted in 1967 posed the question: "The auto pollutes the air, creates traffic, demolishes property, and kills people. Is the contribution the auto makes to our way of life worth this?" Four out of five people questioned answered yes!

In Los Angeles, a model city for air pollution control, a massive reduction in refinery and industrial and open-burning emissions did not make the city's infamous smog disappear. In fact, it became worse. Hydrocarbon pollution dropped at first with the controls applied to the refineries, but in 1960, there was a noticeable increase in this type of pollution. Carbon monoxide in the air kept climbing until today it is four times the 1940 value. When the city began its attack on the air pollution problem, the ratio of pollution was about that in the nation generally: 40% from stationary sources and 60% from motor vehicles.

Eventhough population and industry have doubled in the intervening years, pollution from stationary sources is now only 10%. The remaining 90% is attributable to motor vehicles.

Still more pollution results from lead introduced through production of tires, manufacture of storage batteries, and above all, leaded gasoline. Since no technology exists for the removal of lead from automobile emissions. the only possible method of lead control currently available would be to reduce or eliminate the amount of lead used on gasoline. Besides the possible effects of lead on human health, there is also the possibility that lead iodide in the atmosphere can produce large-scale weather modification, producing increased or decreased precipitation, depending upon meteorological considerations. A major emission from automobiles which affects vegetation is ethylene. Growth retardation in plants is achieved at a concentration of 0.05 ppm for several weeks.

The diesel engine is notorious for the smoke and odor of its exhaust, as testified to by anyone who has been behind a diesel truck in traffic. The diesel units, however, only constitute less than 1% of the U.S. vehicle population. The emissions are deceptive in terms of concentrations since the diesel engine operates on large quantities of excess air that dilute the products. The major emissions are hydrocarbons and nitrogen oxides in addition to smoke and odor. The distinctive odor is caused by **aldehydes which, although annoying, have not been shown to be a hazard.**

When we contrast various modes of travel (see Figure 35), it is interesting to note that jet aircraft produce the lowest amounts of pollutants in pounds per 1000 seat miles under cruise operation. The implication that might be drawn from this calculation is that the United States could increase its aircraft fleet without any worry about polluting the atmosphere. However, in 1968, aircraft were ranked sixth in the production of carbon monoxide, twelfth in the production of hydrocarbons, and negligible in all other areas of pollutants. These figures are based on altitudes below 3,000 feet and a sulfur content of 0.055 percent for the fuel. It was further assumed that only 20 percent of the total fuel was consumed below an altitude of 3,000 feet.

The aircraft pollution problem is a localized one, except for conjectured weather modification along flight paths. The increased air traffic of 400,000 take-offs and landings by jet aircraft at New York City's airports each year, has led to serious pollution problems. The exhaust of smoke, hydrocarbons, nitrogen oxides, and aldehydes are problems that must be faced once again. Aircraft operation at JFK International airport produces from 2-4% of the total particulate emissions that are measured in New York City. At Los Angeles International Airport, traffic has increased from 80 flights to nearly 1000 flights daily over a 10 year period. Statistically, this means that jet aircraft emit almost 80% as much pollution as power plants during the summer months, or 1/4 as much particulates as the daily output of 4 million motor vehicles.

Shock waves generated at supersonic speeds, as well as the increasing number of planes landing and taking off from large airports have created a new health and esthetic problem. Legislation limiting regions of supersonic flight is only a partial approach to this problem. Still unknown is the effect of sonic beem on the ecology of areas of low human population.

During each hour of flight at cruising altitude, which is about 16-22 kilometers in the lower atmosphere, the SST will burn an estimated 66 tons of fuel. This fuel consumption will produce about 83 tons of water, 72 tons of carbon dioxide, and approximately 4 tons each of carbon monoxide and nitric oxide. Most meteorologists agree that gaseous exhaust produced, other than water, will present no special problems. For example, carbon monoxide will be immediately oxidized into carbon dioxide by the generally available OH radicals. The SST will also release hydrocarbons as well as sulfur dioxide, which in the final analysis, will exist in the atmosphere as highly dispersed particulate matter and will form a particle layer at that altitude.

As far as hydrocarbon particles are concerned. we have a very strong suspicion that, due to photochemical action at that altitude, they will slowly be oxidized to carbon dioxide and water, i.e., this type of particle is not persistent. The jet fuel contains on the average of 0.055% sulfur, which is finally converted into sulfates. Assuming a mean residence time for stratospheric aerosol of three years, we can calculate that the total amount of sulfate particles coming from 500 SST's flying for seven and one-half hours per day would only amount to less than one percent of the already existing sulfate pollution in the stratosphere (called the Junge Layer).

Water is more likely to be a problem because stratospheric water concentrations are generally low as the result of condensation in the troposphere. If water added directly to the stratosphere accumulates, it could:

1. Directly change the radiation balance of the earth.
2. Initiate cloud formation and thus increase the amount of solar energy reflected into space, or
3. Lead to the decrease of the ozone concentration of the stratosphere thereby allowing more ultraviolet radiation to

reach the earth's surface.

If one again assumes 500 SST's flying each day and a mean residence time for water vapor of one and one-half years, and that most flights will be in a band from 45° north, calculation shows that water vapor in this limited region would increase from 3 parts per million to 5 parts per million. With added water, corresponding to projected flights of stratospheric aircraft as mentioned above, the ozone column may diminish by 3.8 percent, the transmitted solar power may increase by 0.07 percent, and the surface temperature may rise by 0.04° Kelvin in the northern hemisphere. Temperatures in the lower stratosphere remain essentially unchanged. Even an increase of 10 parts per million of water vapor concentrations would have little effect on ozone concentration. This means the shielding effect of the ozone for ultraviolet radiation reaching ground level will not be greatly disturbed.

The question of whether clouds form in certain regions of the stratosphere could probably be answered by direct observation. In the 1950's, theoretical work and observations of military aircraft provided much information about conditions necessary for cloud formation. It has been concluded on the basis of these studies that the few clouds formed in proposed SST flight bands would produce no serious climatic changes. In 95% of all projected SST flights, the formation of condensation trails from meteorological reasons is not possible. There are, however, extremely cold areas at an altitude of about 17 kilometers in the troposphere, high above the Arctic and the Antarctic, that are thought to be saturated. Because of the saturation, these are potential cloud-forming areas, but no predictions can be made on the basis of our present knowledge since precise information on humidity is not available.

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TRANSPORTATION SYSTEM COMPARISON

(CRUISE OPERATION)

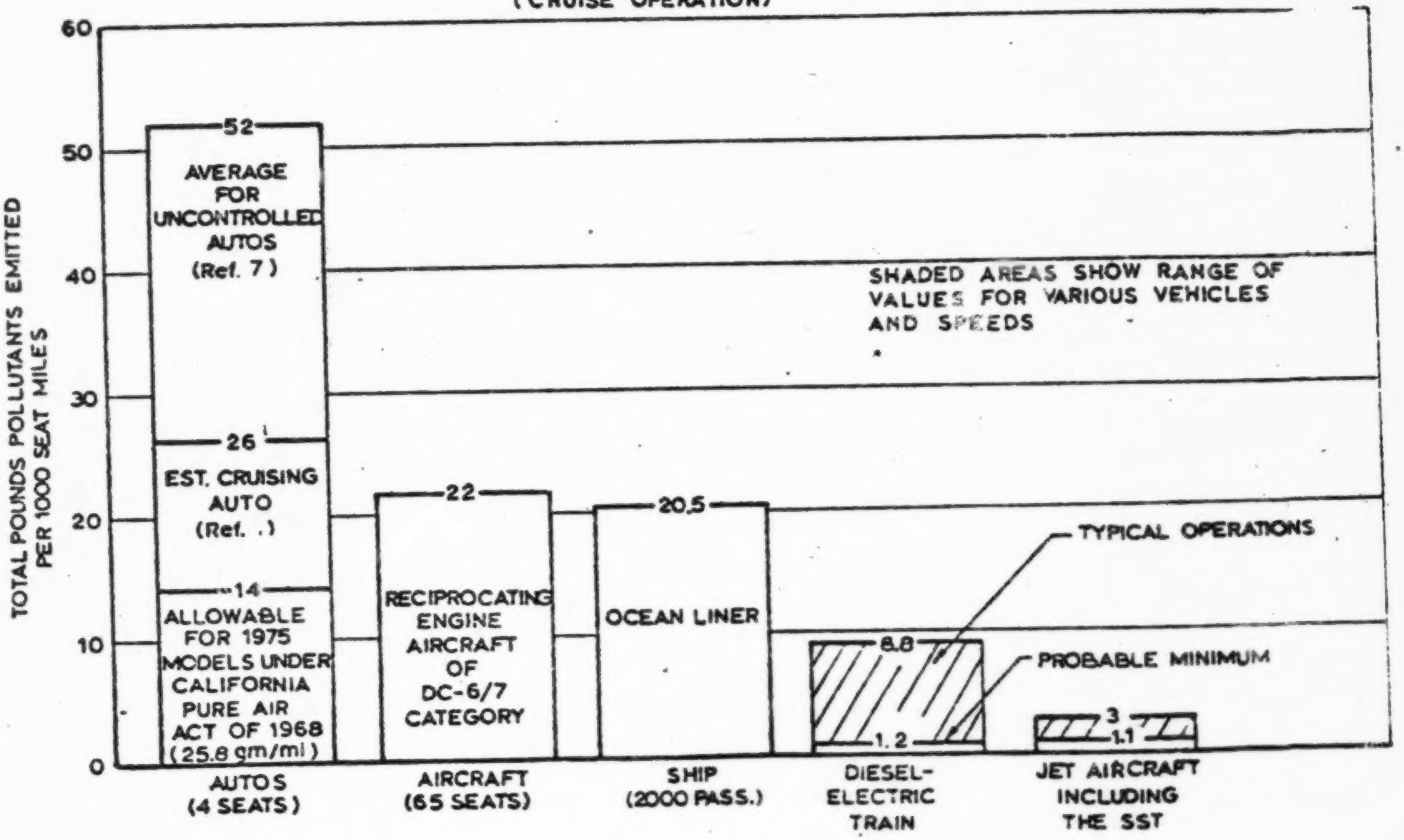


FIG. 35

In summary, it would appear that the pollution and the resulting effects from supersonic transport in the stratosphere is less severe than originally thought. However, the effect of large numbers of aircraft at high altitudes can best be answered by making flights through the proposed region and taking data. Only in this way can accurate and meaningful theoretical work be carried out.

At this time, the elimination of the supersonic transport on the basis of stratospheric pollution alone is not justifiable. More detailed information is needed concerning the flight path, sonic boom danger, length of time subsonic, and number of flights per year.

E. Service Industries

Continued urbanization and industrial growth seem certain to produce strip cities of the future. Existing urban complexes have already been named BOSWASH, CHIPITTS, and SANSAN. The other areas to be named are the Mobile-Jacksonville-Miami strip and the San Antonio-Dallas-Galveston-New Orleans strip. These latter two strips may finally merge into one super strip city. To survive, these congested areas are supplied by service industries. In order to evaluate some of the pollution potential of service industries for these strip cities, it seems appropriate to consider the effects of service industries on New York City. These effects will surely be the minimum for the strip city. In May, 1966, a report on air pollution sources in New York City released the following:

a. There are eleven municipal refuse-disposal stations with forty-seven furnaces and smoke stacks.

b. Public housing, private apartment houses, and office buildings account for 12,666 incinerators and 137,500 heating furnaces.

c. Approximately 13,000 public eating establishments emit smoke and odor at street level.

d. Fuel oil is employed by approximately 600,000 single-double occupancy private dwellings for heating furnaces.

e. The city records the operations of over twenty thousand steamships in New York Harbor each year.

f. Solvent evaporation from dry cleaning is equivalent to 24 tons per day; surface coating - 350 tons per day; and from all others, 176 tons per day. A large percentage of the "all others" category probably is evaporation of dyes and solvents from the printing industry. This is known to be one of the largest polluters of water, and probably also of air.

Incinerators have traditionally been established as far away from inhabited areas as is feasible because of their offensiveness to the optical and olfactory senses. The unpleasantness is two-fold. First, incinerator design has been an unrewarding act for engineers and municipal officials, and secondly, no philanthropist wants an incinerator dedicated to him; at least publicly he doesn't. Most of the pollution problems arise from inefficient operation. For example, few, if any, incinerating plants employ dust collection devices.

The construction of tall apartment buildings to handle the concentrations of population has led to the installation of central **basement incinerators**. The random feeding and intermittent burning has long since been a source of odor. The development of suitable containers for storage before transport to municipal incinerators may be a solution to apartment incineration.

The use of organic fuels for heating furnaces produces the usual smoke and gaseous pollutant problems. The variability of flue height produces a peculiar problem; the effluent from building A may become the "fresh air" for building B. The effect of space heating on the quality of air is greater than would be indicated by the total amount of effluent from this source. Low altitude emission also means that the source is closer to street level where atmospheric mixing produced by the building can bring the pollutant down to the ground. The major problem is to find an effective means to control thousands of multiple sources rather than a few large sources.

New York City has attempted to control its multiple sources by upgrading the older incinerators, by controlling the sulfur content of all fuels, by allowing no incinerators to be installed in newly constructed buildings, by prohibiting all open burning within city limits, and by upgrading and using only municipal incinerators. These efforts have resulted in an estimated cost of 12 million dollars to upgrade the municipal incinerators. However, no warranty existed for the equipment that was to be installed. Following these efforts, apartment owners brought suit against the city charging that the changes required were unconstitutional and imposed unreasonable hardship on the landlord. This litigation has stalled the renovation program. It is estimated that to clean the air in New York City will cost about $500 million by 1972, a figure which equals the estimated 1971 total expenditure for the entire United States.

Similarly, the restaurants represent a problem of multiple small sources of emission. Probably an efficient, low-cost absorption unit for odors would suffice. Filters could effectively collect grease and particles.

To control the smoke and gases from steamships may be very difficult, since this would require international cooperation. A solution might be the establishment of new ports of entry far removed from urban areas with rapid transit hauling goods and people between urban areas and the ports. Since most natural harbors are already occupied, this would pose unusual problems.

It is hard to estimate the total air pollution from the spillage and subsequent evaporation of gasoline and fuel oils by service stations, delivery trucks, and by the transfer of fuel to building storage tanks. Nationally this type of problem will contribute to some degree to the overall background pollution.

There is no difference between constituent airborne particles found in urban and rural air except that rural concentrations are two to twenty times less than urban concentrations.

F. Governmental Activities

The pursuit of national security and world political power has led and still does lead many nations to the atmospheric testing of nuclear weapons. The biological effects of radioactive pollution are difficult to detect since they may be masked by other forms of pollution. However, we know that a material damage can result from radioactive pollution and a definite health hazard does, in fact, exist. The radioactivity forced into the stratosphere exists for a long time and cannot be made harmless by any known means. The tropospheric fallout occurs within a few weeks and contains a large amount of short-lived nuclides such as iodine-131.

The important radioactive elements are strontium-90 and 89, beta emitters; cesium-137, a beta and gamma emitter; carbon-14, a beta and gamma emitter. Strontium-90 is chemically similar to calcium and passes through the food chain, from the plant to man, being deposited in man's skeleton. The principle effect is the increased incidence of bone cancer and leukemia. Cesium concentrates in soft tissues resulting in internal whole-body irradiation, but it does not become fixed in the body. It represents primarily a genetic hazard through irradiation of gonadal tissue.

Carbon-14 is produced from the capture of neutrons by atmospheric nitrogen. This process occurs naturally in the upper atmosphere, or as a result of neutron release in weapons testing. Carbon-14 has increased approximately 30% since the inception of weapons testing; however, the whole-body dose from ingested C-14 is estimated at less than one millirad per year. The greatest hazard probably lies in genetic damage which can occur if the isotope becomes incorporated in the genetic material of the body.

Iodine-131 illustrates an effect characteristic of many air and water pollutants. Inhalation of radioactive iodine has little deleterious effect on the individual because of the isotope's short half-life and low concentration; however, the isotope deposits on foliage consumed by animals such as the dairy cow, which forages over wide areas. Consequently, iodine-131 concentrates in the cow and its milk. Milk-drinking adults and children show marked increases in I-131 in the thyroid gland over persons who were exposed to the same environment but drank no milk.

Radioactive material can be absorbed in various ways. It may be inhaled on dust to permit easy passage to the blood stream and then to a vital organ. The finer particles will remain in the lungs for some time, irradiating neighboring tissue with enough energy to produce damage. Some of the particles are swallowed and enter the gastro-intestinal tract, but radioactive particles absorbed via the food chain, as in the case of radioactive iodine, are more important.

Various other governmental activities, local, state, and federal, contribute to some degree to the overall pollution problem. The establishment of power-generating stations for rural electrification, especially where fossil fuels are the principle energy sources, have led to air quality problems. Recent problems in the southwestern sector of the United States are an example. Governmental assistance in urban redevelopment and road construction have led to local pollution problems. It seems that no long-range planning or methods have been instituted to control air pollution. The use of modular construction of buildings, and the use of demolition techniques which consider minimizing pollution, have been by-passed in our hurry to rectify long-standing problems at minimal costs.

The major function of any government agency in the area of air pollution is the enactment, promulgation, and enforcement of effective control legislation. The Clean Air Act of 1967 establishes air quality control regions. These regions, 91 in number, may be either single or multistate, depending on the particular local problems. Within these regions the states may set standards for pollution levels for the various designated pollutants. If local standards are not enacted, the federal government is empowered to impose standards. These standards are then reviewed by HEW. Most states have established agencies either as separate entities or under state health departments. The designated state agency then conducts hearings where interested individuals may present their briefs. Out of these hearings come the legislation which is passed on to the secretary of HEW and EPA which must then pass judgment on the proposed standards. Next the plans of implementation must be formulated by the appropriate state agency. It should be noted that the standards are set for atmospheric concentrations in the lower level of the troposphere, and the state agency, in order to enforce the regulation, must search out and prove the violation of the standards is caused by specific sources. It would be preferable to set standards at the source, rather than set standards of air quality. Under this procedure it would be the responsibility of the source to maintain its emission level in conformity with the standards. However, since sources of the same type occur in more than one state, such local legislation might lead to an economic imbalance across the nation for a given industry. Federal sanctions throughout the nation on industrial emissions would be an obvious solution, with individual states setting standards for sources that are entirely within their boundaries.

A brief insert is included on the following two pages to survey the history of federal legislation on air pollution, legislation techniques for controlling air pollution, and suggested economic means to control industrial air pollution.

Dangerous levels of air pollutants can be reached at certain times which may require officials to shut down their cities. The public must face the realization that we have to live with dangerous episodes that can hospitalize or kill human beings. However, considerable reluctance to the utilization of emergency powers has been shown by public officials in recent air pollution emergencies in the major cities. An effort must be made to alert the voting public to the dangers of an air pollution episode.

An interesting aspect of the environmental pollution awareness in our society has been the desire of aroused citizens to take offenders into court. Legal action has been an effective method for the prevention of the construction of power plants and industry where environmental damage is feared. In many cases, however, the problem may not be solved by simply chasing the corporation away since the public may demand

Federal Legislation

1. Air Pollution Control Act of 1955

    a. Provided a small program of research and technical assistance to local control districts.
    b. Established the basic policy which assigned primary responsibility for air pollution control to the local and state level.

2. Clean Air Act of 1963

    a. Provided financial assistance for development of state and local air pollution control programs.
    b. Called for national standards for motor vehicle emissions (1965 Ammendments).
    c. Called for maintenance grants to finance state and local air pollution control programs.

3. Air Quality Act of 1967

    a. Called for states to set air pollution standards on a regional basis with local enforcement of standards.
    b. Strengthened powers of local, state, and federal control agencies.
    c. Required that HEW publish air quality criteria for pollutants harmful to health and welfare. Criteria provided states with information for use in developing air quality standaras.
    d. Designated HEW as agency to set air quality regions.
    e. Governor of the states given 90 days to signify intent to set air quality standards.
    f. States given 180 days to hold public hearings and adopt standards, and an additional 180 days to adopt plans and schedules for implementation and enforcement.
    g. HEW designated to review and approve standards.

4. Air Quality Act of 1970

    a. Calls for reduction of 1975 automobile exhaust emission to levels at least 90% lower than 1970 standards.
    b. Establishment of national air quality standards for six pollutants was announced under the Act on April 30, 1970.

Pollutant	Limits
Sulfur dioxide	0.03 ppm
Particulates	260 micrograms/meter^3/24 hr.
Carbon monoxide	9 ppm/8 hr. or 35 ppm/hr.
Photochemical oxidants	0.08 ppm/hr.
Hydrocarbons	0.24 ppm/3 hrs.
Nitrogen oxides	0.05 ppm

c. Implementation plans for all federal air quality regions must be completed by July 1, 1972.
d. Target date for achievement of ambient air standards set at July 1, 1975.
e. Environmental Protection Agency authorized to act in those cases where an imminent threat to health is shown during period preceding completion of state plans.

the services which it supplies. Alternatives to the need for a product or service will require the marshalling of scientific and technical expert witnesses. There is the danger that, if a case should be decided in favor of the defendant, other members of the public would be barred from suing on the same grounds.

The grounds upon which a court may allow a case to be tried is the doctrine of "standing." Under this doctrine, the plaintiff must show a harm which is not suffered equally by everyone else in order to obtain "standing to sue." Recently, standing has been allowed to plaintiffs alleging that the scenic values of their property would be changed by the construction of industrial facilities near their homes. An effective strategy is the addition of an established organization to the plaintiff group. Once the problem of standing is surmounted there are other legal questions that can deny the plaintiff court proceedings, but standing is the first obstacle that must be overcome to bring a case before the courts.

G. Community Activities

Contrary to popular belief, most air pollution is not produced by industrial sources, but rather, non-industrial activities. For example, in a survey of air pollution in Nassau County, New York, it was found that of the 275,000 tons of air contaminants emitted each year, industry contributed only 25% of the total contamination. The other 75% was found to be from domestic and commercial heating, auto and truck transportation, and refuse burning (Air Pollution in Nassau County," published by New York State Air Pollution Control Board, 1966). Included among the community problems that this report acknowledged were: use of residual heating fuels, without properly installed, maintained, and operated equipment; poorly designed and inadequately maintained incineration facilities, as found in apartments, schools, and supermarkets; open burning of trash, leaves, refuse, and other materials, where alternate methods such as compositing, would be suitable; improperly maintained or operated cars, buses, and trucks; antiquated heating systems; and dust and particulate emissions from building construction activity.

The number of established acute air pollution episodes indicates that the air quality of a community can, under the appropriate meteorological conditions, deteriorate to a point where damage to the health of citizens results. These conditions and the effects of air pollution are usually only appreciated after the episode; pre-episode protective measures are rarely taken. The episodes of the Meuse Valley in 1930, Donora in 1948, Poza Rica in 1950, London, in 1952, 1959, and 1962, New York, 1953, 1962, and 1966, New Orleans in 1955, and Minneapolis in 1956, have clearly shown that some controls must be instituted to protect human lives, and if not to eliminate, at least to minimize the effects of the episode. Since 1952, valid measurements have been made during episodes. Also, a federal high air pollution potential forecast system (currently termed HAPP) has been instituted with information being disseminated by the U.S. Weather Bureau.

Besides related deaths and increased respiratory irritation during the episode, the Donora residents affected by the 1948 incident have shown less favorable medical histories than persons that were not affected. There are at least two possible reasons for this. The exposure had long-term effects, or these people would have had a less favorable history anyway. Evidence is not conclusive on this point.

Many metropolitan areas are faced with increasing amounts of refuse and fewer and fewer landfill sites at greater and greater distances from collection points. As a result, greater reliance has been placed on central incineration. Since complete combustion rarely occurs, soot, smoke, hydrocarbons, aldehydes, sulfur oxides, hydrogen chloride, and nitrogen oxides are added to the air. Theoretically, it is possible to capture all solid materials produced in dust collectors and to have complete combustion; however, even under ideal conditions, combustion produces local imbalances of gaseous pollutants.

One example of desirable municipal incineration is operated by the community of Oceanside, New York. This incinerator burns garbage to produce steam and electricity and to produce fresh water from the nearby saltwater. The refuse of a half million people is incinerated to produce 3,000 kilowatt hours of electricity, steam, heat, and 460,000 gallons of fresh water per day. The plant is equipped with a cyclone-type control to remove soot, ash, and chemicals from stack exhausts. In addition, the salt-free water it produces is used in scrubbers which clean the smoke from the plant.

One activity of the construction industry that has contributed to air pollution is the demolition of thousands of buildings to make way for urban renewal and highways. Much of the refuse produced from this is burned on the site with resultant addition of contaminants to the air. In December, 1965, New York City prohibited open burning of this waste lumber.

Before the ordinance went into effect on January 1, 1966, four city burning sites had accepted an average of 485 truckloads of demolition wastes per week. Under the regulation, wrecking contractors were required to cut the waste lumber into three-foot sections and pack it solidly to eliminate holes where fires could start and rats could live in the sanitary landfill sites. In the first week following the ban, only 331 truckloads of debris were hauled to landfill sites. Building sites throughout the city became small mountains of splintering lumber. A spokesman for the Building Trades Employees Association expressed the bitterness of the wreckers who were hurt by the city's actions: "It seems they singled out this industry. Everyone can see that the air pollution lumber creates is infinitesimal compared to other sources." (Henry Sill, The Dirty Animal, p. 43). His comment is typical of every company and every individual who is against pollution of all kinds, but resists any controls on his particular activities.

The disposal of solid waste, which amounts to about 5.5 pounds per capita per day in the United States and may, in fact, be as high as 10 pounds per capita per day, represents a problem because of the method of disposal. In 1968, 367 million tons of solid waste were disposed of in the United States. Approximately 50% was disposed of by municipal incineration, on-site incineration, open dump burning, and wigwam burners. The on-site incineration and open dump burning accounted for more than 70% of all disposal by burning. It is very difficult to control such a large number of point sources.

Urban planning, if possible, should consider the location of industrial and municipal sources of air pollution as well as economic factors. Zoning can lead to dilution of emissions and reduction of the potential for a pollution incident. The downwind side of the urban area is the logical zone for air pollution sources. Attention should be paid at the same time to placement of the plant in locations of minimal downwind population. In the case of service industries, central locations dictate more stringent control. Air pollution is less a problem of urban congestion than of urban sprawl, which, itself, intensifies the problem by requiring an increase in transportation, by elimination of potential downwind locations, and by creating the need for new pollution control zones which could require movement of established industries. Also, urban sprawl increases the number and decreases the size of combustion sources as well as increasing the number of municipal governments that must be coordinated. Increasingly, walking, bicycling, and public transit have become less effective means of transportation within an urban sprawl.

The use of proper insulation materials, if large expanses of glass are to be used in northern latitudes, and the use of roof overhang in southern latitudes, can greatly reduce the space heating and cooling requirements of a community. Gas burning is usually found to produce the minimum of air pollution. The limited amount of this resource and the expense of piping or transportation limit its use. Electrical heating of a home or building produces no direct air pollution, but does require increased output from power plants and the resulting air pollution from consumption of fossil fuels.

Bans on open burning of dumps are imposed eventhough methods exist for providing relatively clean exhaust gas. Primarily, this ban was instituted because the problem of fly ash emission from open burning has not been overcome. Domestic backyard incinerators have given way to trash removal and landfill sites. The problem of the taxpaying person who loves to burn leaves because the smoke smells nice still remains, eventhough open burning has been banned in many states. Some pollution results from the open fireplace burning of coal and wood. In England, this type of burning is a major contributor to urban air pollution.

H. Recreational Activities

Industrial man has an average life expectancy of 70 years. He has gained an extra 20 years of life since 1900, with a commensurate potential increase in leisure time. In fact, his total leisure time is approximately equivalent to the average life expectancy of primitive man (see Figure 18).

This increased "free time" has led to the very rapid increase in recreational areas: parks, golf courses, beaches, ski resorts, etc. The location of these sites is limited by available land, clean water, and adequate snowfall. Usually, these facilities are far removed from the habitats of the potential users. The problem of transportation to the facilities, and the pollution generated by this transportation add to the problems which have already been explored. Rapid mass transit, in place of individual autos, could be one solution. Multiple facilities have been constructed to extend the recreational use to almost a full year. A possible solution, where climatologically possible, would be continued construction of resort areas near cities in order to use operating public and private conveyance. The construction of hills, using solid waste, and the creation of artificial swimming areas have already been tried. If these synthetic areas take on an artificial Christmas tree look, will our aesthetic senses accept this ersatz facility?

The number of people engaging in leisure and recreational activities has demanded that industry produce more products for these areas. Industry, therefore, considers new, cheaper, and more efficient methods of producing and improving its products. There has been an increased use of synthetics, some of which derive from materials that used to be thrown out because there was no use for them. We are now entering areas where no one knows the consequences of some of the processes being used in terms of potential sources of air pollution.

The American society lives with a paradox: the desire to go back to and get out in nature while dragging with it all the industrial paraphernalia. Roads must be cut through national parks in order to provide access for camping trailers, mobile homes, and the large numbers of people that have taken up camping. There is apparently something beneficial to just being outdoors under an open sky and so we construct stadiums where people can sit and watch. We promote electric golf carts and snow mobiles, neglecting the beneficial aspects of exercise. In Yellowstone National Park, increased particulate counts have been noted since the introduction of snow mobiles to the area. How long will an area remain clean and natural before our pursuit of recreational and leisure activities leads to its pollution? How many areas have requested the institution of walking, bicycling, and riding trails?

Summary

Man's contribution to pollution of the atmosphere is a product of several factors, all of which must be considered if the situation is to be alleviated. Primary among these factors is gross population. But population as a contributing factor must be considered in terms of the psychological, social, and economic factors, which cause it to cluster in complex urban societies. Intricate technological societies place increased demand on our resources and produce increasing quantities of wastes. The waste products from energy release are particular problems in the area of air pollution. In part, the solution may be found, at least on a short-term basis, in the utilization of cleaner energy sources. Ultimately, the solution seems to lie in a reordering of social structure--a process which has occurred historically as a gradual response to increased environmental pressures.

IV Student Oriented Activities

We have divided the activities into five sections. Section A deals primarily with the construction of simple instrumentation to be used in the projects suggested in section B or in investigations evolved by the user. It should be noted by the teacher that the exercises in B, C, D, E are neither exhaustive in their scope nor sacrosanct in their methodology. They are designed to be suggestive of activities that may be undertaken by individuals and/or classes and may be refined, adapted or restructured to fit the needs of a particular class, locale or student. It is the hope of authors that once started the student might originate his own area of investigation and experimental design.

The social science activities and humanities activities are rather unique for a manual of this type. All have been used in various classes, grades seven through twelve--again never exactly in the same fashion on two different occasions. We have included some other activities in section E. Some of these activities such as the air sampling project are new but have been used widely. Except in instances where a particular exercise was needed to complete the development of an investigation, we have avoided the inclusion of exercises already in print. Credit is given in the text in cases of adaptation of published or unpublished exercises. A list of other manuals of this type which you should obtain follows:

Hunter, Donald C. and Wohlens, H. C., Air Pollution Experiments for Junior and Senior High School Science Classes, 1968. Air Pollution Control Association, 440 Fifth Avenue, Pittsburgh, Penna. 15213

Soporowski, J.J. (Editor) Air Pollution Experiments, 1967. College of Agriculture and Environmental Science, Rutgers University, New Brunswick, N.J. 08903

Lyons, Yolande (Editor) Experiments for the Science Classroom Based on Air Pollution Problems, 1962. Department of Public Health, State of California, 215 Berkeley Way, Berkeley, Cal.

Weaver, Elbert C. (Editor) Scientific Experiments in Environmental Pollution, 1968. Holt, Rinehart and Winston

_______ Air Pollution Study Program Manual, 1970. Eduquip Inc. 1220 Adams St., Boston, Mass. 02124

A. Measurements, Data Collection and Instrument Construction

1. Wind direction indicator
2. Anemometer
3. Hair Hygrometer
4. Rain Gauge
5. Photocell - milliameter radiation detector
6. Air Pump Calibartion
7. Electroscope - environmental chamber
8. Louvered shelter
9. Smog Box
10. Cold Chamber
11. Audiometer
12. Condensation nuclei counter
13. Acoustical Particle counter
14. Diagrams of home-made weather instruments
15. Diagrams of photoelectric cell and sound level meter

A-1 Wind Direction Indicator

I. Introduction

The wind direction (the direction from which the wind blows) can be sensed by smoke drifts, flags, and a wind vane. The wind vane is designed to point in the direction from which the wind is blowing; i.e. if the vane points N.E., it is a N.E. wind.

II. Objectives

1. To determine the local pollution movement patterns through the atmosphere (e.g. pollen, gases, particles)

2. To correlate wind direction with pollutant trends from foil studies

III. Materials

glue, nails, glass beads, 1/2 inch dowel rod - 18 inches long, support stick - 5 feet long, two pieces of tin-can metal 4 inches x 7 1/2 inches, arrow tip from tin-can metal 2 1/2 inches x 4 1/2 inches and a piece of tin-can metal 1/2 inch x 4 inches long and a compass (see A-14: A-1 diagram)

IV. Procedure

Slot ends of dowel rod. Nail arrow tip to one end and both 7 1/2 inch x 4 inch pieces to the other end. Spread feather end so that the two sheets are three inches apart and secure by bending the 1/2 inch x 4 inch piece of metal and glue. Balance vane on knife edge and drill hole through the dowel rod at the balance point. Insert loosely fitting nail through dowel, then glass bead and hammer into stand rod. Mount the compass on the base of the stand and by sighting read the wind direction. Galvanized sheet metal will not work. If tin-can metal is not available, aluminum flashing will work very well.

A-2 Anemometer

I. Introduction

The wind speed at a given location can be estimated from the Beaufort scale (Appendix F-1) or an anemometer can be made and calibrated.

II. Objectives

1. To determine the wind patterns in a particular geographic area

2. To determine the distance particulates have traveled.

III. Materials

three aluminum funnels 2 1/2 inches wide, three 3/16 inch dowel rods - 7 inches long, one plastic pen cap, metal lid from ink bottle or olive jar, nail, metal washer - 3/8 inch diameter, glue, flat black paint and three pieces of tin-can metal 2 1/2 inches x 5 inches for a high speed anemometer (see A-14: A-2 for diagram)

IV. Procedure

The funnel spouts are cut off and the ends are cut-bent over and sealed with solder. Drill 3/16 inch holes in the funnel rim and push dowel rod through and glue. Trisect the metal lid and drill three 3/16 inch holes in the rim. Insert dowel rod until a total length of 7 inches exists from center of cap to edge of funnel. Drill hole in center of cap to just fit the pen cap. Push pen cap through lid and between dowel rods. The washer is glued to the dowel rods and pen cap. The hole of the washer should be in line with the pen cap. A three inch nail sharpened at both ends is used to support the apparatus. One end pounded into the support and then file the other end into a sharp point. For a high speed anemometer use the tin-can metal instead of the funnels.

Calibrate by attaching it to a broomstick and drive in an automobile at various speeds and count the revolutions per minute at each speedometer reading and graph RPM vs MPH for easy reference and conversion.

A-3 Hair Hygrometer

I. Introduction

Water vapor in the atmosphere is an important variable that is necessary for the production of precipitation. The ratio of the amount of water vapor actually present in the atmosphere to the amount of water vapor that the saturaturated atmosphere could hold is known as the relative humidity. A useful instrument for measuring relative humidity is a hair hygrometer.

II. Objectives

1. To determine the relative humidity of the atmosphere.

III. Materials

empty 1/2 gallon milk carton, glue, blond hair, broom straw, sewing needle, ruled paper for scale and washer (see A-14: A-3 for diagram)

IV. Procedure

Cut one side out of the carton and glue end of blond hair to the bottom of carton (see A-14). Cut flaps in next side of the carton and insert sewing needle through the bent out flaps. Wrap the hair twice around the needle and glue the hair to the washer. Push the sharpened end of the broom straw through the eye of the needle. Paste the ruled paper on the carton behind the broom straw. Calibrate the ruled paper by comparison to a sling psychrometer or other available hygrometer. Instead of waiting for wide variations of relative humidity to occur in the classroom, it would be better to take the hygrometer to various locations that would exhibit different humidities during a laboratory period.

A-4 Rain Gauge

I. Introduction

Any cylindrical can may be used to catch precipitation; however, to determine the rainfall to the nearest 1/100 of an inch, it is necessary to magnify the depth of the rain catch. This is done by use of some devise such as the plastic rain table or metal can rain gauge.

II. Objectives

1. To determine the effectiveness of rain or snow scavenging in removing atmospheric pollutants

2. To study precipitation patterns

III. Materials

two large juice cans, 1 inch thick styrofoam - cut in a circle to fit inside the can, 5 inch diameter plastic funnel, glue, and shielding material

IV. Procedure

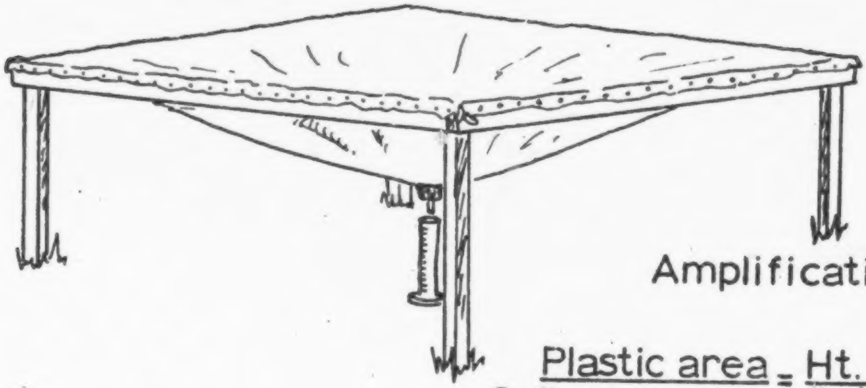
Cut both ends out of one can and one end from the second. Solder or epoxy the two cans together. Insert funnel into styrofoam and place styrofoam into opening. Glue shield material to rim of funnel and to sufficient height to extend beyond the can opening. Mount the finished gauge on a platform with wooden stick extending above the platform halfway up the rain gauge. Tie rain gauge to the stick. The apparatus should be placed as far away from any objects as the objects are high. In order to measure the precipitation, the water collected is poured into any other can of much smaller diameter called the measuring tube. Precipitation is calculated according to the following relationship:

$P=H(d/D)^2$ where P=depth of precipitation
d=inner diameter of measuring tube
D=inner diameter of funnel top
H=height measured in the measuring tube

Snow fall is collected in any open can but of larger diameter. Two cans from commercial foods can be used or remove the funnel from the rain gauge. Melt the snow by adding a known depth of warm water and subtract from the resulting measured value.

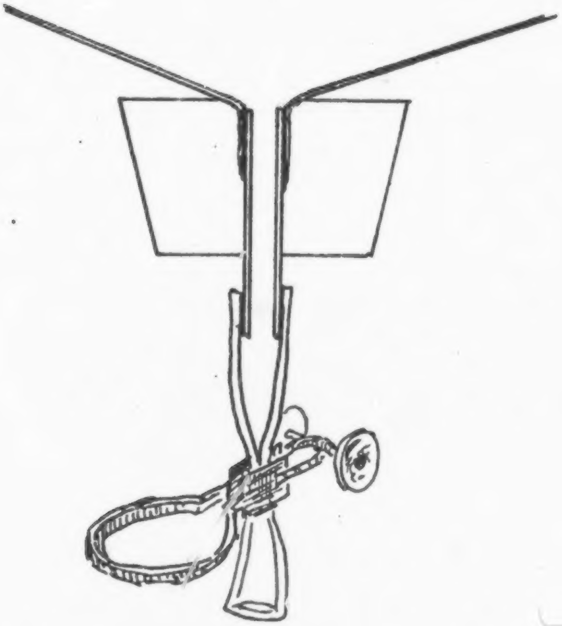
Instead of making the suggested rain gauge, the plastic rain table in the following diagram could be constructed. This would serve for both the collection of rain and snow. If both are constructed, it would then be possible to compare the two instruments as rain gauges.

PLASTIC RAIN TABLE



Amplification ratio

$$\frac{\text{Plastic area}}{\text{Collector area}} = \frac{\text{Ht. of water}}{\text{Am't rain fall}}$$



A-5 Photocell - Milliameter Radiation Detector

I. Introduction

In many cases, radiation from a source can be used as an indirect indicator of the amount of pollution in the atmosphere.

II. Objectives

1. To measure radiation coming from sky on gross basis
2. To measure radiation reflect or scattered from various pollution materials
3. To study cloud cover

III. Materials

watch glass, block of wood, bell wire, binding post and photoelectric cell

IV. Procedure

The photo electric cell* may be enclosed in an inverted watch glass on a block of wood with the two wires led out to binding posts (see A-15 for diagram)

The photo electric cell may be connected to a continuous recorder such as a Rustrak Recorder and placed outside a window or on a roof and a continuous record of changes in radiation levels may be kept for a period of time. These results may then be correlated with other observations and data collected to identify trends in cloud cover and pollution levels.

To calibrate the instrument you need a light source which produces a parallel beam of light, a slit aperture which emits only a narrow bundle of rays and a wooden box to hold samples vertically. Place a piece of shiny white paper in the holder and let the reflected light impinge upon the photo cell. Use any appropriate electrical measuring device of adequate sensitivity such as a dc. milliameter. Use a sample of black crepe paper or velvet to give a zero reading. The calibration should be carried out in the dark if a zero value is to be assumed. A graph of voltage versus intensity can then be made to calibrate the photo cell. Assign maximum value of 100 and use a linear scale.

*A photo light meter calibrated in foot candles may be substituted for the photo cell. However, the student then does not have the opportunity to build and calibrate an instrument that he may use to measure with.

A-6 Air Pump Calibration*

I. Introduction

You will need to calibrate a vacuum pump before using the pump to draw air through a sampling device. This calibration will allow you to describe your data per unit volume. A flow rate meter can be used for this purpose or the following procedure.

II. Objectives

1. To gather air samples for qualitative and quantitative study
2. To teach calibration of an instrument

III. Materials

two gallon jugs, vacuum pump, stop watch, rubber tubing, glass tubing and water

IV. Procedure

Use two gallon jugs connecting the vacuum pump to one of the containers. A siphon tube is connected from this container to the second container. The first container is sealed and the second one is left open. The siphon is completely filled with water and both ends of the siphon are placed beneath water but in different containers. Measure the change in volume of liquid in both containers per unit of time by some suitable means and average for several trials. Calculate the flow rate in liters per minute and cubic feet/second.

Notes on Experiment

1. Gallon jars are ideal for the large bottles needed in the calibration.

2. If a vacuum pump is to be calibrated, extreme caution must be exercised not to create a vacuum which will cause the closed bottle to implode. The vacuum pump should be run for only a few seconds to prevent implosion.

*Source - Weaver, E.C. ed. Scientific Experiments in Environmental Pollution, New York, Holt, Rinehart & Winston, Inc., 1968.

A-7 Electroscope - Environmental Chamber

I. Introduction

In many cases before field work is begun it is necessary to experiment under controlled conditions. An environmental chamber is a satisfactory method for containing atmospheric pollutants with minimal danger. A method of detecting the amount of pollution in the chamber at various times is also advantageous when pollutants and their concentrations is desired.

II. Objectives

1. To determine the mobility of ions in polluted air

2. To determine the effects of a polluted environment on plants and materials.

III. Materials

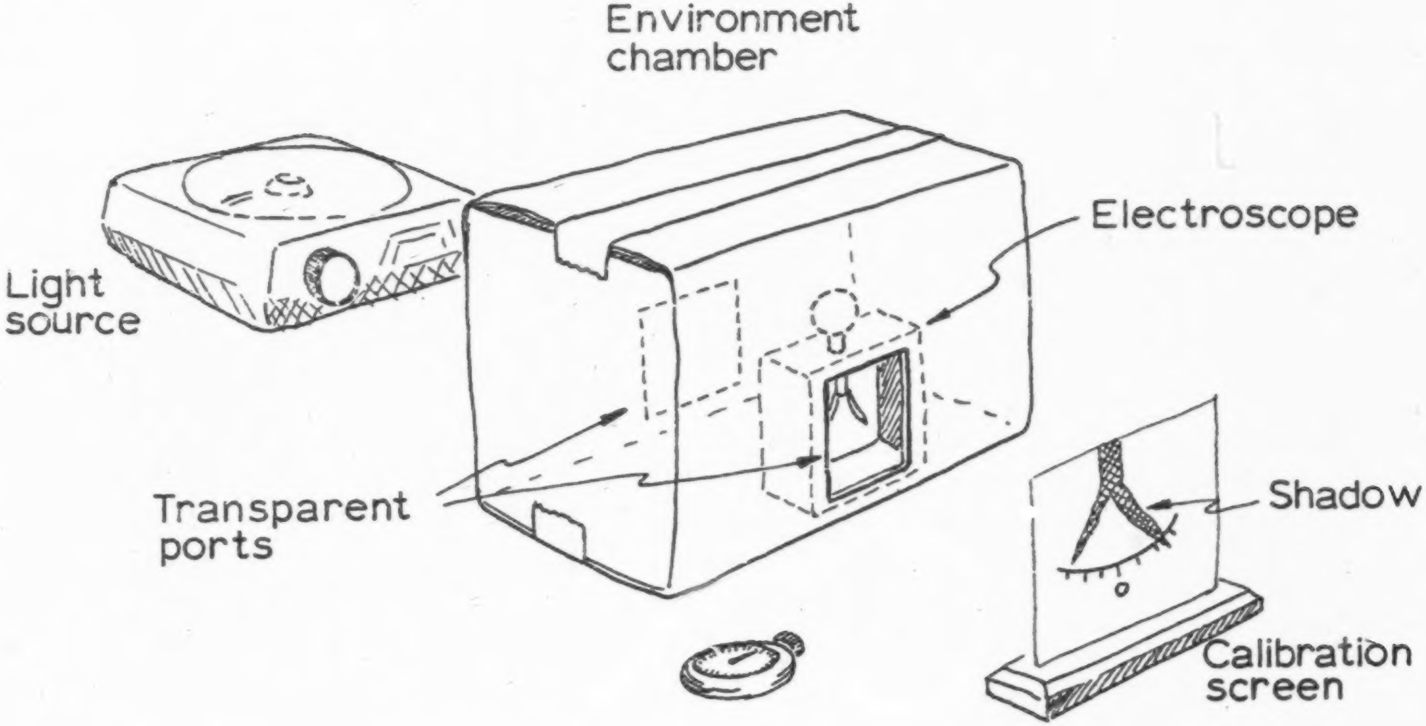
electroscope, environmental chamber (cardboard box), light source (filmstrip projector), screen (white paper or cardboard), sources of pollutants to be added to the air (dry ice, smoke, SO_2, etc.)

IV. Procedure

Refer to the accompanying diagram. The box used for the environmental chamber has two windows cut in it, one in the front and another in direct line with the first, in the back. These are covered with transparent plastic or clear wrap to keep the chamber sealed. The electroscope is so positioned that the light source placed outside the chamber will cause a shadow of the leaves to fall on the screen. A scale is drawn on the screen to take readings. (The method of placing a charge on the electroscope should be determined by the student.) The scale is determined by placing a maximum charge on the electroscope and getting the maximum deflection of the leaves. The lowest charge and therefore least leaf deflection is also marked on the scale. The calibrated scale can then be used as a standard for future trials.

The teacher should encourage the student to be as creative as possible in designing modifications of this apparatus to get finer more accurate measurements or to branch out to other investigations.

APPARATUS FOR MEASURING ELECTRON LEAKAGE


Environment chamber
Light source
Electroscope
Transparent ports
Shadow
Calibration screen

A-8 Louvered Shelter

I. Introduction

Certain material damages caused by air pollutants can be mimicked by other causal factors. The effects of sunlight, high temperatures and hot particles from exhaust stack can be eliminated by placing test materials in a louvered shelter.

II. Objectives

1. To house materials to be tested for long term pollution effects

III. Materials

two (2 1/2 feet x 3 1/2 feet x 1/2 inch) pieces of marine plywood, 4 - 2 inch hinges with screws, 1 1/2 inch wood screws, 8 - 18 inch pine louvered shutters and cans of white spray paint

IV. Procedure

Build a rectangular enclosure approximately 5 feet above the ground. The sides should be louvered to keep out direct sunlight and other weather effects and one side should open. (The use of inexpensive louvered pine shutters will simplify the construction.) The enclosure should be large enough (2' x 3') to hold experiments and should be placed in an open area such as in a field or on a roof top. The roof of the shelter should be of a shed type and the entire structure should be painted white.

A-9 Smog Box[*]

I. Introduction

In many instances, it is better to work with atmospheric pollutants under controlled conditions. This minimizes errors which might produce hazardous side effects. Also it is then possible to study certain effects and familiarize oneself with monitoring equipment before working in the environment.

II. Objectives

1. To demonstrate the acidity of various gases in the atmosphere

2. To introduce students to the use of gas sampling tubes in order to practice determining of gaseous concentration in the atmosphere[**]

III. Materials

cardboard carton, masking tape, glass tubing, atomizer

IV. Procedure

The box is a cardboard carton which is air tight at all corners and edges. Tape if necessary to insure that the box is air tight. In the center of one side push the glass tubing, which is connected to a wash bottle, into the box and tape the tube to the box. The wash bottle should be aspiratored by a hand pump. On the opposite side make a hole large enough to accomodate the nozzle of a spray atomizer. The atomizer contains dilute sulfuric acid. Cut a flap in the top and place an evaporating dish in the box. In the evaporating dish place copper and cover with dilute nitric acid. Punch a few holes with a nail in the sides of the box to admit air. Squeeze the atomizer every 30 seconds and begin aspiration. Discard smog box after use.

CAUTION: Should be done in a hood or under good ventillating conditions.

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[*] Source: Weaver, E.C. ed., Scientific Experiments in Environmental Pollution

[**] See Exp B13-B

A-10 Cold Chamber

I. Introduction

The atmosphere has many cleansing processes which aid in the removal of pollutants. However, the pollutants themselves may interfere with the triggering devices for the cleansing processes. Air pollutants may then be a cause of inadvertant weather modification.

II. Objectives

1. To demonstrate cloud formation

2. To study ice crystal formation

3. To show the effects of various pollutants on ice crystal formation

4. To demonstrate other factors and processes which affect ice crystal formation

III. Materials

styrofoam ice chest, black paper or black velvet or black water base paint, dry ice, beaker, warm water, light source.

IV. Procedure

Obtain an inexpensive styrofoam ice chest and line it with black paper or paint its inside surface with water soluable black paint. Place a chunk of dry ice in the bottom and a container of warm water in the chest. Close the top and allow the atmosphere inside to saturate with water vapor. Open the top and shine a narrow intense beam of light down into the chest or make a narrow slit inside of the chest and lining.

A-11 Audiometer

I. Introduction

Increasing population, technology and changing social patterns have resulted in an interest in the danger of noise level. More and more people are beginning to realize that a feeling of well being can be influenced by noise. Of practical concern is the problem that hearing loss induced by intense noises may not be reversible.

II. Objectives

1. To measure sound levels at various locations

2. To determine acceptable limits for sound levels by comparison to standarts determined by various studies

III. Materials

amplifier (see procedure), microphone, potentiometer (5k), diode, resistor (100), component mounting box (5 1/2 x 3 1/2 x 3 1/2), capacitor (1 microfarad) and 50 micro amp meter

IV. Procedure

Obtain a small amplifier such as an RCA CA3033 or Realistic 277-1240 which sell for under $5.00 each. Connect the amplifier as shown in diagram A-15. The meter should be made to deflect full scale at various sound levels (by adjusting the potentiometer). Standard levels of sound for calibration in decibels may be reproduced using an audiometer available from most school nurses. Lower and upper limits of sound intensities may be determined and the instrument calibrated with enough accuracy to make comparisons between sound levels at different locations possible.

The instrument may be used to get relative sound levels without calibration in decibels, if an audiometer is not available. The direct reading of the scale in microamperes at various locations of differing sound levels will give an accurate relative sound level.

As a comparison standard the following list of noise levels may be used as a rough calibration in decibels:

* Noise Levels	db
Threshold of hearing	- 1
Normal Breathing	- 10
Leaves rustling in the breeze	- 20
Whispering	- 30
Quiet office	- 40
House	- 45
Quiet restaurant	- 50
Conversation	- 60
Automobile	- 70
Food Blender	- 80
Niagra Falls at base	- 90
Heavy automobile traffic, or jet aircraft passing overhead	-100
Jet aircraft taking off, or machine gun at close range	-120

*Ehrlich, Paul R., Ehrlich, Anne H.: Population, Resources, Environment - Issues in Human Ecology (W.H. Freeman Company, San Francisco, 1970).

An excellent article for reference on sound levels and other sound effects can be found in Scientific American - December, 1966.

A-12 Qualitative Condensation Nuclei Counter

I. Introduction

The number of condensation nuclei in the atmosphere at any moment is a good indication of the pollution of a locality. The higher the concentration of particles, the greater the pollution of the atmosphere. Most of these particles are produced primarily by automobiles and although the same particles are found nationally, the numbers vary depending upon the environment. The greatest concentrations are in cities and the lowest over the oceans or in the center of a vast forest.

II. Objectives

1. To construct a portable instrument to be used to detect condensation nuclei in various environments
2. To estimate the amount of pollution due to small particulates
3. To emphasize adiabatic processes in science

III. Materials

empty soda can, water, nail

IV. Procedure

Punch a small hole in the side of an empty soda can close to the bottom rim of it. Place a small amount of water in the can (one teaspoon full) and swirl to saturate the air. Covering the opening in top with your mouth inhale once or twice. This will introduce particulates into the can. Cover the opening on top with your mouth and put a finger over the nail hole. Exhale into the can. Maintain the pressure for five seconds. Release pressure and hold the can so that you can view particles in the beam of light coming through the nail hole. By estimating distance between the particles, with a little practice, you can determine the number of condensation nuclei per unit volume. For example, if the particles are 1/10 cm apart, then there are 1,000 particles per cm^3.

A-13 Acoustical Particle Counter

I. Introduction

Many times a demonstration is needed to generate enthusiasm and motivate students. The acoustical particle counter is such an instrument since it can be used to detect particles on seemingly clean materials. It can also be used as a quantitative instrument to measure particles larger than 10 microns.

II. Objectives

1. To provide a count of particles above 10 microns in a sample of air drawn through it

2. To provide motivation

III. Materials

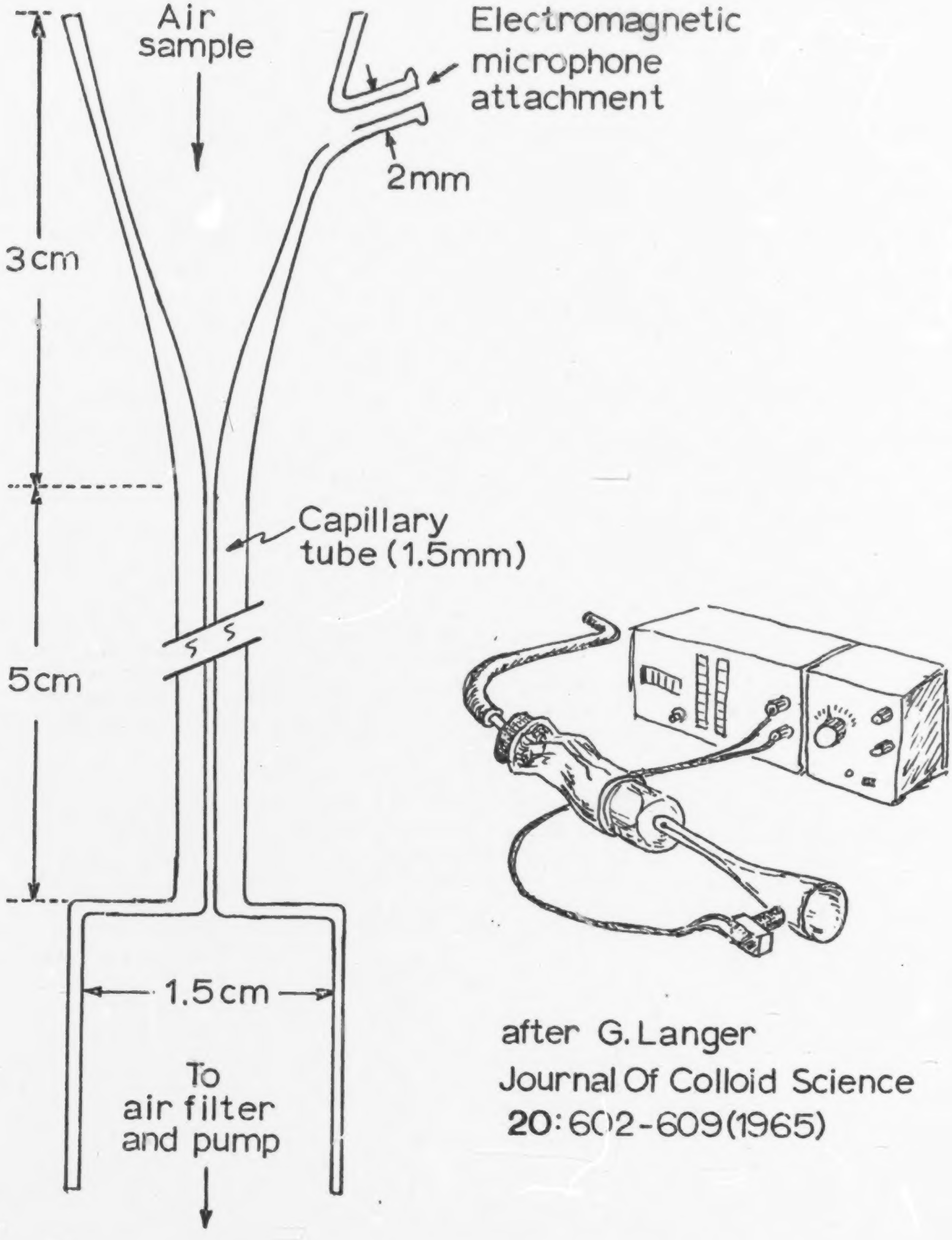
acoustical counter (see following diagram or obtain from E. Bollay Assoc., Inc. Boulder, Colo.), inexpensive microphone, digital counter (or eight decade counter coupled with an amplifier power supply), vacuum source

IV. Procedure

Set up the equipment as shown in the following diagram. The acoustical particle counter should be calibrated to determine the air flow in a given time. This may be done using an air flow meter available from most scientific supply houses. Other means of calibration may be devised by the student and this should be encouraged.

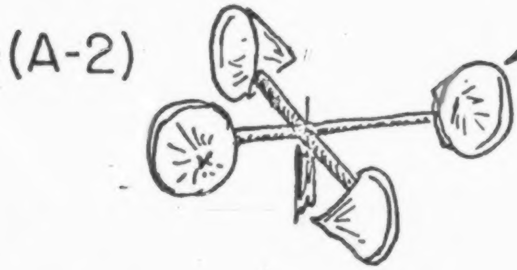
The counter can be used to sample air from outside a window or in various locations around the school building. The data collected can be analyzed on a statistical capability or graphical basis. Comparison for various times of day or different locations would be appropriate as possible activities. Electric fields around the tube might be tried to separate various types of particles.

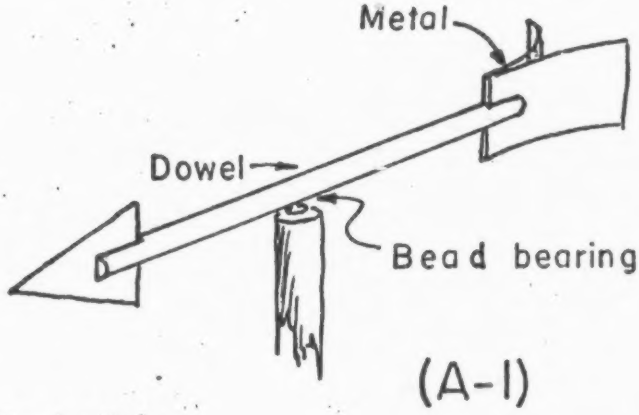
ACOUSTIC PARTICLE COUNTER

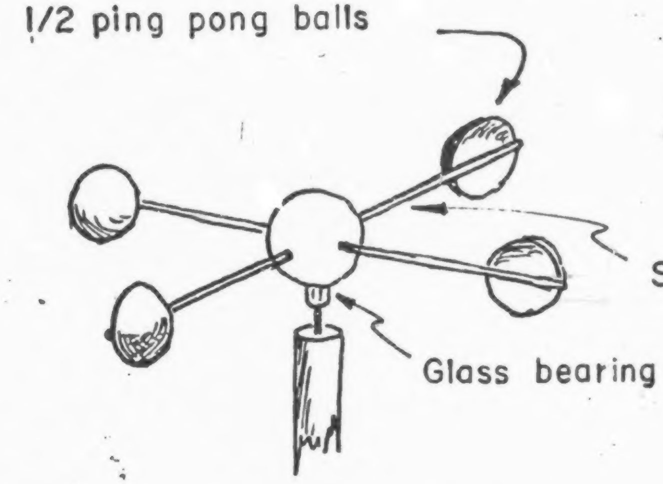

Air sample
Electromagnetic microphone attachment
2mm
3cm
Capillary tube (1.5mm)
5cm
1.5cm
To air filter and pump

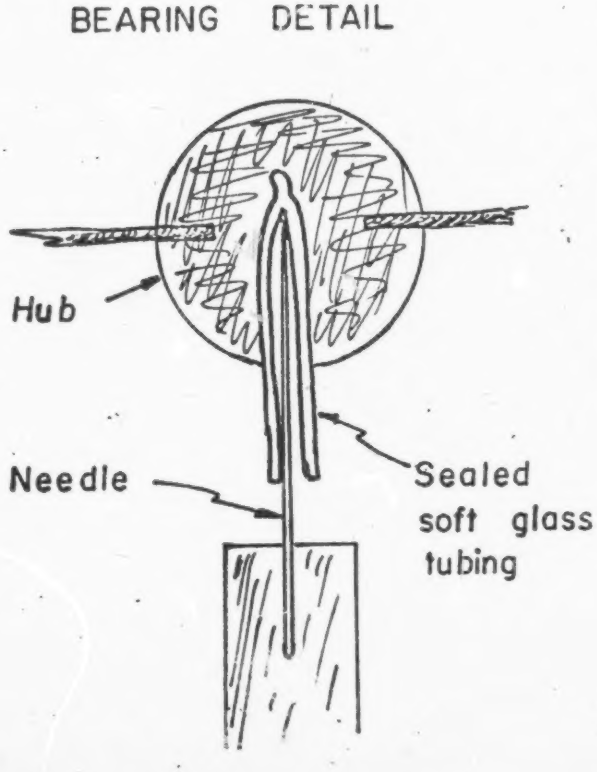
after G. Langer
Journal Of Colloid Science
20: 602-609(1965)

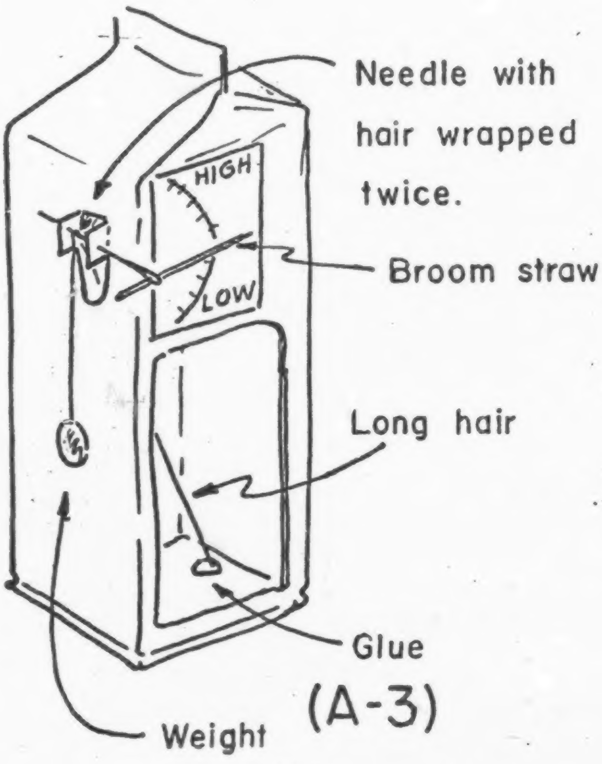
A-14 HOME-MADE WEATHER INSTRUMENTS


(A-2)
Aluminum funnels

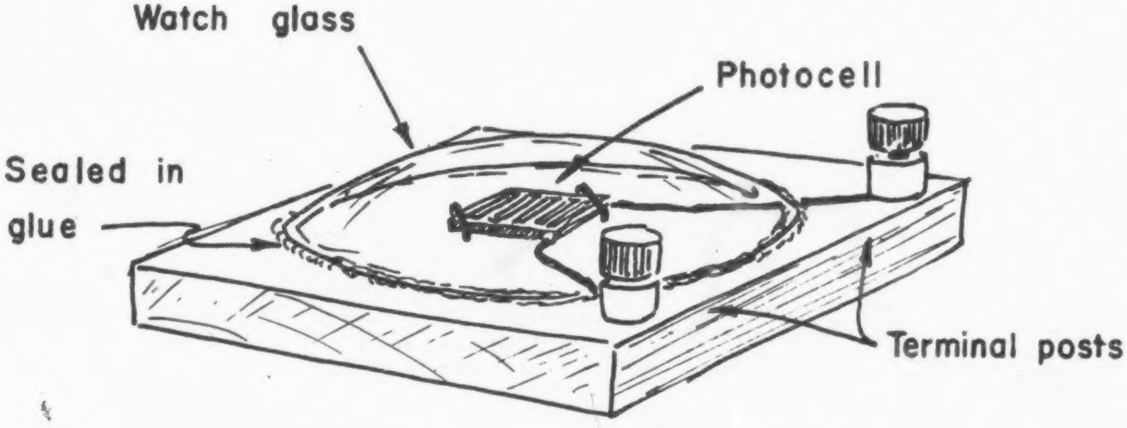

Metal
Dowel
Bead bearing
(A-1)


1/2 ping pong balls
Swab sticks
Glass bearing

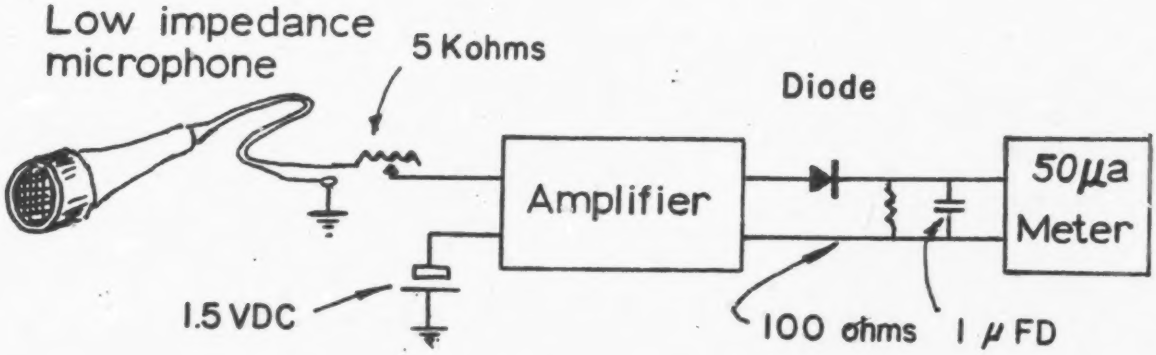

BEARING DETAIL
Hub
Needle
Sealed soft glass tubing


Needle with hair wrapped twice.
HIGH
LOW
Broom straw
Long hair
Glue
Weight
(A-3)

A-15 PHOTOELECTRIC CELL


Watch glass
Photocell
Sealed in glue
Terminal posts

SOUND LEVEL METER


Low impedance microphone
5 Kohms
Diode
Amplifier
50μa Meter
1.5 VDC
100 ohms
1 μ FD

B. Science Projects - Experimentation and Data Analysis

(Student Projects)

1. Determine Smoke Shade
2. Pollution and Visibility Effects
3. Calculation of Ventilation
4. Vertical Motion in the Atmosphere
5. Effect of Electric Field on Charged Particles
6. Estimation Suspended Particulates
7. Ozone and its Effect on Rubber
8. Artificial Weather Modification
9. High Volume Sampling
10. Suspended Particulates
11. Dust Fall
12. Cleansing Action of Natural Processes
    Rain Scavenging - T.Norton
13. Measurement of Pollution Effects
    a. electrical - Dave's electroscope
    b. plant damage
    c. material soiling
    d. material damage
    e. insolation depletion
14. Testing for Radioactivity in the Atmosphere
15. Determining the Size of Particles
16. Analysis Using Sedimentation Foil Data

B-1 Determining Smoke Shade*

I. Introduction

Combustion of organic fuels, if complete, would yield only carbon dioxide and water vapor; however, combustion is never 100% complete under ordinary conditions. Particles of unburned carbon and colorless gases are released from the source as atmospheric pollutants. The unburned carbon produces a plume that varies from gray to black in color.

A standard procedure for estimating the amount of blackness of a smoke plume was established by M. Ringelmann. The Ringelmann standards are a series of grids which when compared visually with the smoke allows one to estimate blackness from 20% to 80%.

II. Objectives

1. To test for smoke emitted from stationary sources.

2. To realize the problems associated with the Ringelmann chart.

III. Materials

microringelmann chart. (These grids may be purchased from Power, 330 West 42 Street, New York, N.Y. 10036 @ 35¢ each).

IV. Procedure

1. Select a site not closer than 100 feet from the stack nor greater than 1/4 mile from the stack.

2. The background behind the stack should be free of dark objects.

3. Directions for the microringelmann chart are printed on the back of the chart.

V. Date and Results

1. Fill in the following table from measurements made 1/2 minute apart. At least 20-30 measurements should be taken.

Ringelmann number	number of observations	product of R.N. x N.O.
0		
1		
3		
4		
5		

Sum of products________

Total number of observations =

2. Compute the weighted average Ringelmann number of the smoke

$$\text{wt. R. no.} = \frac{\sum(\text{R no.} \times \text{no. of observations})}{\text{number of observations}}$$

VI. Questions

1. If a plume doesn't exist or is completely white, is there any danger of air pollution?

2. What color plume would the addition of excess amounts of water vapor to the stack effluent produce?

3. Are there other techniques for producing a colorless plume and still have particles emitted from a source?

* Source: Air Pollution Experiments for Junior and Senior High School Science Classes: Edited by D. Hunter and H. Wohlers
A.P.C.A.
4400 Fifth Avenue
Pittsburgh, Penn. 15213

B-2 Pollution and Visibility Effects

I. Introduction

Aerosols in the atmosphere absorb, reflect and scatter light which results in a marked reduction of visibility. The extent of the scattering of light is influenced strongly by the number and size of particles in the air. When the particle is of a size equal to half the wavelength of light(about 1/4 micron) the light is efficiently scattered.

Water condenses on dust particles, salt nuclei and other types of condensation nuclei. Since some particles are hygroscopic, a fog can be formed even though the air is not saturated with water vapor. Reduced visibility at 90% R.H. or higher is almost always the result of water droplets; however, below 70% R.H. pollution must be considered the principal factor.

II. Objectives

1. To correlate visibility variations and air pollution.

III. Materials

hygrometer, topographic map.

IV. Procedure

Obtain a good map of the surrounding area and a humidity measuring device (Hair Hygrometer). Select a good position for observation that will allow you to identify landmarks 1/4, 1/2, 3/4, 1, 2, 5 and 10 miles distant. Each day or several times a day, establish your visibility and record R.H., wind direction, time of day, time of year, and local weather patterns. Discount all decreases in visivility when relative humidity is greater than 70%.

V. Data and Results

1. Construct a table for the variables listed in the procedure.(visibility, R.H., Date-Time, wind direction, local weather)

2. Try and establish patterns between degree of pollution, source of pollution, time of day, season and current weather pattern.

B-3 Calculation of Local Ventilation

I. Introduction

Large cities or industrial complexes depend upon large volumes of moving air to carry away pollutants downwind and to dilute the concentration of the pollutants. Under low wind speeds and inversion layers adequate ventilation of the locality may not occur and a potential pollution hazard can be produced quite rapidly.

The ventilation over an area is the product of the maximum mixing depth, which is the height to the inversion determined by a dry adiabat drawn through this depth, and the average vertical wind speed through the mixing depth. Ventilation of less than 3,000 m^2/sec is considered hazardous.

II. Objectives

1. To help the student understand that an inversion by itself may not produce a hazardous condition.

2. To help the student understand that low horizontal wind speeds and a low inversion lid produce hazardous conditions.

III. Materials

radiosonde sounding data or included data, pseudo-adiabatic chart.

Sample Data

P(mb)	T(^oC)	Wind Speed(Knots)
1000	19	2
990	18	3
970	16	5
940	28	10
850	21	25
710	10	20

Note: A pseudo-adiabatic chart may be purchased from the U.S. Dept. of Commerce WB Form 770-11.

IV. Procedure

1. Obtain a radiosonde sounding with wind speeds from your local weather bureau or use the above data.

2. Plot the sounding data on the pseudo-adiabatic chart.

3. Follow the dry adiabatic line from the 1000 mb, 19^oC point until the dry adiabatic line crosses the sounding.

V. Data and Results

1. From the height scale at the right side of the chart, determine the maximum mixing depth.

2. Compute the average wind speed through the maximum mixing depth layer.

3. Calculate the ventilation

V = M.M.D. x Average Speed

VI. Questions

1. Does the continental weather pattern indicate what type of inversion is affecting your locality? What additional information would you need to definitely establish the mechanism producing the inversion?

2 How would you weigh the importance of inversion height versus wind speed? Does this depend upon surrounding terrain, source of pollution and size of city?

B-4 Vertical Motion in the Atmosphere

I. Introduction

Surface materials absorb insolation at various rates depending upon their albedo. When a parcel of air becomes buoyant with respect to surrounding ambient air it is forced aloft by pressure differences and vertical up drafts are created. The parcel, if it is large enough and rises rapidly enough, can be considered to be undergoing adiabatic motion. The parcel will continue to rise until its identity is lost or until an equilibrium is reached with the ambient atmosphere.

This type of motion is important since it is a main mechanism for transporting pollutants aloft where the pollutants can be rapidly dispersed and diluted.

II. Objectives

1. To make determinations of vertical motion in the atmosphere

2. To determine rate of ascent over various types of land forms

3. To demonstrate that vertical ascent and descent can occur side by side in the atmosphere

4. To demonstrate that vertical ascent is more vigorous than descending air unless the descent is produced by obstacles (e.g. mountains, buildings).

III. Materials

supply of natural gas, toy balloons, soda straws, two tripods, protractors, cardboard, plum bob, screws, 4 x 8 x 1" plywood (See attached diagram).

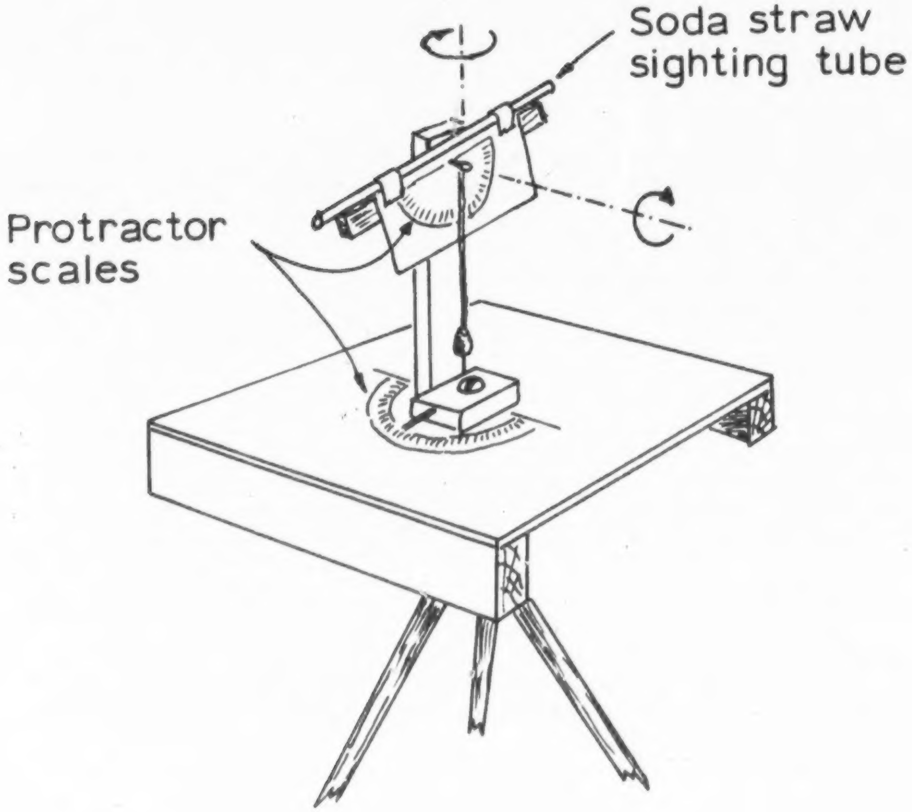
IV. Procedure

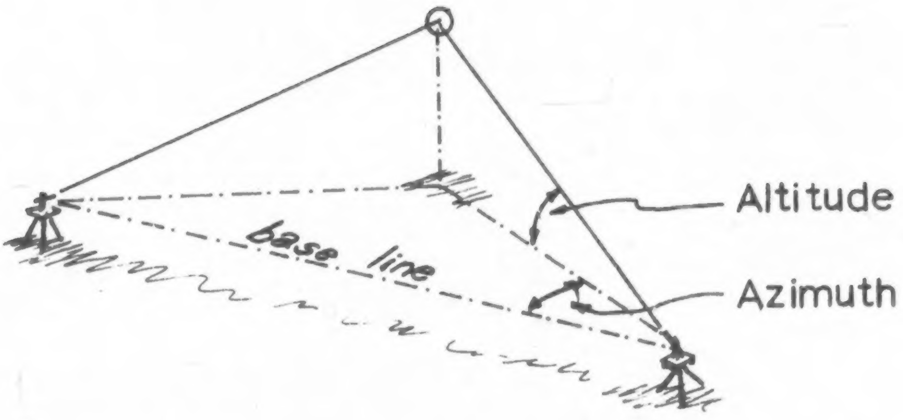
Use a hand aspirator attached to a natural gas jet to fill toy balloons. Tie and weigh so that they have slow ascent rates. Build two simple transits (see diagram).

Lay off a 200 foot base line, place the transits at each end and orient the transits with respect to each other. A team of 3 observers and a recorder is assigned each transit. A balloon of very small positive buoyancy is released at transit height from the center of the base line and both azimuth and elevation angles are read and recorded every 15-30 seconds.

The base line can be coordinated with local wind conditions such that lift rate can be measured over various types of land forms, asphalt parking lot, grass play area, wooded area, freshly plowed earth, and water surfaces.

SODA STRAW TRANSIT
(THEODOLITE)


Soda straw sighting tube
Protractor scales


base line
Altitude
Azimuth

V. Data and Results

A. Horizontal wind speed

1. Plot the points representing the positions of the theodolites (call them T_1 and T_2) according to a scale laid out on a piece of graph paper.

2. Plot the sight lines at the end of each time increment from the theodolites (T_1 and T_2) to the balloon's position.

   a. The recorded azimuth angles from each theodolite at the end of each time increment are plotted on the graph with the vertex of each plotted azimuth angle being the position of the theodolite from which it was read (T_1 or T_2). One side of the angle is the base line and the other side is the sight line from that theodolite.

   b. The point of intersection of the two sight lines is the point in the plane of the theodolites at which the balloon is located.

3. Measure the horizontal displacement during the time increment.

   a. Measure the distance between the positions of the balloon at the beginning and end of the time increment using the same scale as the graph paper.

4. Determine the average wind direction during each time increment and determine the average wind velocity during the time increment.

B. Vertical wind speed

1. Plot the points representing the positions of the theodolites (T_1 and T_2) according to a scale on a piece of graph paper.

2. Plot the sight lines at the end of each time increment from the theodolites (both T_1 and T_2) to the position of the balloon.

   a. The recorded elevation angles from each theodolite at the end of each time increment are plotted on the graph with the vertex of each elevation angle being the position of the theodolite from which it was read (T_1 or T_2), one side being the base line and the other being the sight line from the theodolite.

   b. The point of intersection of the sight lines is the position of the balloon at the end of that time increment (B_1, B_2, etc.).

3. Determine the perpendicular distance between the position of the balloon at the end and at the beginning of the time increment.

V. Continued

4. From #3, determine the rate of ascension of the balloon in feet per minute for each minute of flight.

VI. Questions:

1. Talk to glider pilots, if possible, to ascertain if strong vertical motion is ever noted by them.

2. How would you evaluate your local atmospheric conditions during the experiment and observed rates of ascent?

3. Would you expect rapid rates of increase when your location is under the influence of a high pressure system?

4. Thermal lows give rise to large scale vertical motion; can you list some phenomena expected from this type of motion?

5. What would you hypothesize would happen to the water vapor from a hyperbolic cooling tower associated with a nuclear power generating plant under cold front conditions?

Source: After R. Ward & W. Broland

B-5 Effects of an Electric Field on Charged Particles*

I. Introduction

An effective way to remove particulates from a stack is by means of an electrostatic precipitator. Suspended solids may carry an electric charge or be charged by contact with ions produced by an electrode. When charged particles are passed between plates carrying opposite charges they are attracted to the plate which has the opposite charge. After impaction the particle remains on the plate.

II. Objectives

1. To study one method by which particles may be removed from the atmosphere.

III. Materials

2" diameter metal tube or 2" diameter glass tube, aluminum foil, non-conducting stands, clamp, metal rod, induction coil or Whimshurst generator, bell wire, alligator clips.

IV. Procedure

Clamp the metal tube or glass tube wrapped with aluminum foil (cut a window for viewing) about 12 inches off a table. Make sure that the stand supporting the tube is non-conducting. Center a metal rod in the chimney and support the rod from the insulated stand. An induction coil or Whimshurst generator can be used to establish a potential difference between the chimney and the center rod.

Smoke may be introduced into the chimney by burning camphor in an evaporating dish, burning shoe polish, burning a wick that has been soaked in turpentine or by producing a chemical smoke by allowing ammonia water and hydrochloric acid vapors to react. Tobacco smoke produces some startling effects, also.

*Source: Hunter & Wohlers Manual

B-6 Estimating Suspended Particulates

I. Introduction

Aitken nuclei are believed to have a weather modification effect since they may serve as condensation nuclei. Large numbers of particles may enhance precipitation or, conversely prevent precipitation if large numbers of nuclei are present. In any case, Aitken nuclei are indicative of the amount of pollution in a given area.

II. Objectives

1. To measure the variation in condensation nuclei as a pollution indicator.

III. Materials

Qualitative condensation nuclei counter, acoustical particle counter.

IV. Procedure

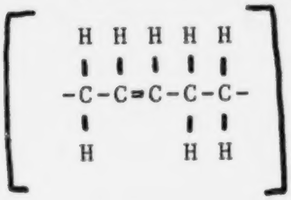
Using the qualitative condensation nuclei counter, students may establish numbers of nuclei simultaneously in different locations. Wind direction, sources of pollution and counts can be plotted on a topographic map. Analysis over a period of days can be made to establish patterns. An interesting project would be to monitor different parts of the school building to establish hypotheses for variations observed. The acoustical particle counter can be used at fixed locations around the school over a period of time to give a size distribution to be used in conjunction with the qualitative condensation nuclei counter data.

B-7 Ozone and its Effects on Rubber*

I. Introduction

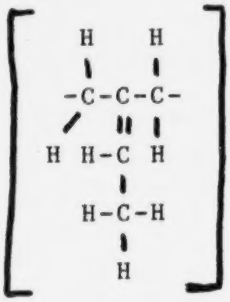
Rubber is a natural polymer used in hundreds of articles essential to our modern civilization. The rubber molecule is made up of many small units, C_5H_8, linked together. This molecule is unsaturated which means that there are not enough hydrogen atoms to satisfy all of the valence bonds of carbon. This results in two carbon atoms of C_5H_8 repeating unit being linked by a double bond. Two examples which might occur are:

(a)



$$\left[-\underset{H}{\overset{H}{C}}-\overset{H}{C}=\overset{H}{C}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\right]$$

(b)



Ozone, although present in small amounts reacts vigorously with the double bonds oxidizing the molecular chain. This occurs most rapidly when the rubber is stressed. A good example is the cracking observed in rubber tires. This problem has been overcome to some extent by the production of synthetic rubbers.

II. Objectives

1. To study the effect of ozone on rubber.

III. Materials

rubber ozone sensitive sheets (from Goodyear Tire and Rubber Co., 1356 Tennessee Avenue, Cincinnati, Ohio), louvered shelter, 375 grams of mass, ozone generator, environmental chamber, vernier caliper, magnifying glass.

IV. Procedure

1. Cut the rubber sheet into strips 1/16" x 2". Store the unused rubber in a sealed container in a cool, dark place.

2. Suspend the strips in a louvered shelter with 375 grams attached to one end of the rubber strip. Expose the strips for 7 days and remove from the shelter.

An alternative method is to construct an ozone generator and pump the air into an environmental chamber. Follow the above procedure for suspending the rubber strips in the environmental chamber.

V. Data and Results

1. Mount the rubber strip horizontally under the same tension as when the rubber strip was suspended.

2. Examine the surface for cracking with a magnifying glass.

3. Measure the depth of cracking with a vernier caliper.

4. Use the depth of cracking as a relative indicator of ozone concentration.

VI. Questions

1. Did you notice any cracking or checking in the rubber which was under tension?

2. Does the exposed strip of rubber return to its original shape as well as an unexposed strip?

3. Can you find any other materials that are chamically attacked by ozone?

*Source: Hunter & Wohlers Manual

B-9 High Volume Sampling

I. Introduction

A quick way to sample the air for suspended solids is to use the High Volume Sampling technique. This gives a quantitative measure for the degree of particulate pollution in an area. Since many of the particulates are dark in color the collected sample can readily be seen. This material upon impaction with surfaces will lead to the discoloration of buildings in your locality.

II. Objectives

1. To measure the amount of suspended particulates in the atmosphere and compare with other rural, suburban and urban areas

III. Materials

fiber glass filter, Buchner funnel, rubber tubing, louvered shelter, calibrated vacuum system, analytic balance, dessicator

IV. Procedure

Cut a piece of fiber glass filter to fit inside of a Buchner Funnel and hold the filter in place with a piece of rubber tubing. The funnel is placed in the louvered shelter and connected to a vacuum system. The filter should be desiccated at room temperature for 24 hours and its mass found to the nearest 0.1 mg. using an analytic balance. With the filter in place calibrate the vacuum system. Let the system run for a period of time (24 hours if possible). Calibrate the system again with the filter in place. The air flow rate is the average of the two readings. Again desiccate the filter for the same period of time as done originally and find its new mass. Express your result as micrograms/cubic meter.

V. Data and Results

1. Record volume rate and mass of the filter at the beginning of the experiment.

Volume Rate = liters/minute
Original Mass = milligrams

2. Record volume rate and mass of the filter at the end of the experiment.

Volume Rate = liters/minute
New Mass = milligrams

3. Find average volume Rate

$$\text{Average Volume Rate} = \frac{\text{Volume Rate}_1 + \text{Volume Rate}_2}{2}$$

4. Find mass difference

Mass Difference = New Mass - Original Mass (micrograms)

5. Calculate suspended particulates

Suspended Particulates =

$$\frac{\text{Mass Difference}}{\text{Average Volume Rate}} \times \frac{1}{\frac{60\ \text{min.}}{\text{hour}}} \times \frac{1}{\text{hours run}} \times \frac{10^6\,\text{cm}^3}{\text{m}^3} \times \frac{1\ \text{liter}}{10^3\ \text{cm}^3}$$

VI. Questions

1. How does your value compare to average values for other areas?

B-10 Suspended Particulates *

I. Introduction

Wind blown particles in the range 20-100 microns can be observed visually after they are collected. The direction from which the greatest number of particles come can be ascertained and correlated with industrial sources upwind. These particles do not enter the lungs but are responsible for soiling in the community. The particles collected are in the region between those particles which remain suspended and those particles which sediment out rapidly.

II. Objectives

1. To visually determine the number of particles suspended in the atmosphere.

III. Materials

stand, container 2 3/4" diameter x 3" high, Fassons Pli-A-Print R135 adhesive paper which can be obtained from Fasson Products Division of Avery Paper Co., 250 Chester Street, Painesville, Ohio. Cincinnati Visual Standard A-3 photograph obtained by writing to the Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226.

IV. Procedure

Mount the container on the stand. Cut a strip of adhesive paper 2" x 10" from the Fasson's paper. The adhesive paper is wrapped around the outside of the container. The stand is placed, removed a distance from obstacles at least equal to the height of the obstacle. The cardinal compass points are marked on the adhesive paper for reference. After a seven day exposure the surface of the adhesive paper is sprayed with a clear lacquer and removed from the stand.

The number of particles per square inch can be obtained by comparison with the visual standard photograph.

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* Source: D. Hunter & Wohlers Manual

B-11 Dust Fall

I. Introduction

Dusts and other solids present in our atmosphere have many sources. Natural sources (pollen, soil, volcanic dust) are picked up by the wind and may be distributed worldwide. Man's activities (e.g. construction, refuse disposal, power generation) introduce large amounts of particles into our atmosphere. Particulate emission may be the most serious pollution problem of the atmosphere for a given locality.

The particles in the atmosphere have a size and mass distribution (see Section F - Appendix) that allow some particles to remain suspended and others to settle out onto surfaces. We shall be concerned with particles greater than the 100 micron size.

The amount of materil settling out gives an indication of the local pollution and cost to the individual and community through soiling of surfaces.

II. Objectives

1. To determine the mass of solid particles settling onto a surface during a given period of time.

III. Materials

glass jar with mouth diameter greater than 4 inches, stand to hold jar upright, algacide.

IV. Procedure

Clean the jar and add 5 ml of algacide solution to the jar to retard growth of algae. Place the jar on a suitable surface, well away from any structures. The jar is exposed for 30 days and then the contents are analysed.

Remove any extraneous materials from the jar. Scrub the inside surface of the jar and wash it down with measured amounts of hot distilled water. Place the sample in a beaker on a hot plate and evaporate to a small volume of liquid. Use a steam bath to evaporate all visible liquid. Cool the beaker and find its mass to the nearest 0.1 mg. Subtract the mass of the beaker to obtain the residue which was deposited.

V. Data and Results

1. Record grams of material/cm^2/month.

VI. Questions

1. What was the area of exposure?

2. What were the total settleable particulates expressed as mg/cm^2/30 days?

3. What is your result expressed in pounds/acre/30 days?

4. What control could have been used in this experiment?

5. How does your area compare with the following classification?

slight dust fall	0 - 0.7 mg/cm^2/month
moderate dust fall	.7 - 1.4 mg/cm^2/month
heavy dust fall	1.4 - 3.5 mg/cm^2/month
very heavy dust fall	greater than 3.5 mg/cm^2/month

B-12 Cleansing Action of Natural Processes

I. Introduction

Precipitation is an excellent scavenger of pollutants found in the atmosphere. Solid particulates may serve as condensation or ice nuclei and liquid aerosols may be removed by accretion. Gases will be removed by photochemical processes, adsorption or absorption in water. The precipitation will remove the pollutants and cleanse the air. However, since the imput of pollutants into the atmosphere is continuous the cleansing action is a temporary one. Also, the pollutants are brought down to the surface of the earth in a concentrated form where they present a different type of pollution problem.

II. Objectives

1. To determine whether or not precipitation removes pollutants from the atmosphere

2. To determine the most effective size of raindrops for optimum cleansing

III. Materials

p-H paper, nylon stocking, 9 inch hoop, confectioner's sugar, rain gauge or plastic rain table, jars with tops, Kodak linograph paper

IV. Procedure

Collect rain in the gauge or rain table using some predetermined time interval, (e.g every 15 minutes for light rain and every minute for a thunder shower). Snow may be collected and melted, again using appropriate time intervals. Use p-H paper to analyse the acidity of the rain water as a function of time. Set the individual samples aside and these may be analysed for particulates with a meter or analytical balance (see exp. B-11).

Place the nylon over the 9 inch hoop and fasten to the hoop. Sprinkle powdered sugar on top. Expose the hoop to the rain for a short time. The rain drops pass through the mesh and take the sugar with them. The sizes and numbers of rain drops may be easily determined. An alternative method uses linograph paper.

V. Data and Results

1. Fill in the following tables:

Reading	Time	pH	gm of particulates

2.

Reading	Time	pH	particle size	# of particles	gm of particulates

VI. Questions

1. How does the P-H compare with the duration and amount of precipitation?

2. How does P-H compare with the size distribution found in various rain falls?

3. Is there an optimum size of raindrop for the most effective cleansing of the atmosphere?

4. How does particulate mass compare with duration, size of raindrop and amount of precipitation?

5. Is wet or dry snow a more efficient scavenger of air pollutants?

B-13 Measuring the Effects of Air Pollution

A. Electrical

I. Introduction

Polluted air is a poor conductor since it captures charged particles. Also, as the number of particles increases, the mobility of the ions decreases and a charged electroscope will not discharge as quickly as in clean air.

II. Objectives

1. To study the effects of various atmospheric pollutants on electrical charge and mobility of ions.

III. Materials

Electroscope - environmental chamber, various pollutants (See diagram in A-7)

IV. Procedure

The general procedure to be used is to introduce various atmospheric pollutants into the chamber and time the collapse of the leaves of the electroscope. There are many approaches as to how this might be accomplished and it is here that student ingenuity and creativity should be relied on to set up the experiment to accomplish his goal.

There are many variables and the control of those not being tested should be explored by the student. The data collected will be determined by the student's project design and the interpretation should be done by the student based upon his reading in the literature and the data he obtains from the experimental procedure.

V. Data and Results

1. Plot rate of collapse of electroscope versus pollutant.

VI. Questions

1. Which pollutant affects the mobility of ions the most?

2. If the concentration of each pollutant is known, is your answer the same as in #1?

B. Plant Damage

I. Introduction

Gases account for the majority of injury to vegetation. Ozone, PAN, nitrogen dioxide, hydrogen fluoride, ethylene and chlorine may inhibit growth, destroy plant chlorophyl or disrupt the photosynthetic process.

Pollutant	Part of Leaf Affected*
Ozone	Palisade
PAN	Spongy cells
NO_2	Mesophyll cells
SO_2	Mesophyll cells
HF	Epidermis of mesophyll
Cl_2	Epidermis of mesophyll
CH_2	All

*Refer to Section II for cross-section diagram of a leaf.

II. Objectives

1. To study the effect of various concentrations of gaseous air pollutants on sensitive plants

III. Materials

Obtain specific gas sampling tubes from:

Unico, Inc.
P.O. Box 590
Fall River, Mass. 02720

or

Eduquip Inc.
1220 Adams Street
Boston, Mass. 02124

microscope, environmental chamber, laboratory gas demonstration bottles, camera, color film and infra red film, seeds or plants specific for various gases (see Section F - Appendix), ventilation

IV. Procedure

Grow or obtain sensitive plants for the various pollutants to be tested. Set aside one plant to be used as a control and place another plant in the environmental chamber. Put the environmental chamber in a hood and introduce the pollutant gas. Monitor the concentration of the gas over a 1-4 hour period(e.g.every 1/2 hour). The greater the concentration of gaseous pollutant the shorter the plant exposure that is needed.

Photograph the control and exposed plant over a period of days under identical conditions. Note any damage indicated by the photographs or observed visually and study a section of the leaf under a microscope.

B. Continued

V. Data and Results

1. For each plant list:

   a. plant
   b. time of exposure and pollutant concentration
   c. photographic evidence of damage
   d. complete description of visual damage and any prepared slides that were made.

VI. Questions

1. Which part of the plant was affected by each pollutant?

2. Does varying the concentration and exposure time produce any notable changes in plant damage?

3. What are the effects of mixing two or more pollutants and exposing the plant to the combination.

4. Are there any noticeable growth or morphological effects?

5. Check the literature for estimates of the cost of vegetative damage from air pollution in the United States. What are these estimates? How do they compare over the past 10, 20, 30 years?

C. Material Soiling *

I. Introduction

Polluted air contains many particulates which are dark in color and can be readily seen when taken from the air. These particles cause soiling of fabrics. It is estimated that every person spends \$50-\$75 a year in additional cleaning bills because of air pollution. In large cities, the cost may run to \$125 per person annually.

II. Objectives

1. To estimate soiling of filter samples over a period of time and during various parts of the year.

III. Materials

vacuum pump, two pieces of 28 mm glass tubing, 50-75 mm long with 1.2 mm wall thickness, window screen 28 mm in diameter, two rubber stoppers to fit 28 mm tubing with 8 mm hole in center, two pieces of 8 mm diameter tubing 75 mm long, masking tape, Whatman #41 filter paper: 28 mm diameter, flow meter, gallon jug, funnel, photocell-milliameter radiation detector.

IV. Procedure

Place the screen on one end of the 28 mm tubing followed by the filter and the other 28 mm piece of tubing. Seal the joint with the masking tape. Stopper the ends of the tube and insert the 8 mm tubing in each stopper. Connect the side opposite the screen to the funnel and the other end to the flow meter, gallon jug and vacuum system.

Start the pump and record the beginning flow rate and time. When the filter is darkened sufficiently, turn off the vacuum system and record the flow rate and time.

V. Data and Results

The clean filter paper can be considered 100% reflectant for light measured with the radiation detector. From prior calibration the % reflectance (R) of light can be found for the sample filter and the optical density calculated by:

$$\text{Optical density} = \log_{10} \frac{I_0}{I_R} = \log_{10} \frac{100\%}{\%\ R}$$

or

$$\text{O.D.} = 2 - \log_{10} \%R$$

C. Continued

VI. Questions

1. How does the optical density vary at different sites and times of the day/year?

* Source: D. Hunter & H. Wohlers Manual

B-13 Continued

D. Material Damage

I. Introduction

The stability of colors in dyed fabrics can be affected by sunlight, washing, heat and humidity. Oxides of nitrogen and ozone are also causes of fading.

The usable life of nylon goods is shortened by air pollution. The factors which may affect nylon are:

1. hot particles from chimneys
2. sulfurous or sulfuric acid mists
3. nitrogen oxides
4. phenols and aldehydes
5. solvent vapors

Metals are rapidly attacked by many gaseous pollutants when the temperature, concentration or relative humidity are high. Under any or a combination of the above factors, the metals undergo chemical reactions known categorically as corrosion.

II. Objectives

1. To study the effect of atmospheric pollutants on:
   a. nylon
   b. colored fabric
   c. metals

III. Materials

photocell-milliameter detector, nylon hose, 4 x 5 polaroid mounts, copper, steel and zinc sheets, louvered shelter, AATCC Gas Fading Control Fabric and Color Fastness to Ozone: Available from:

Test Fabrics, Inc.
55 Vandarn Street
New York, New York 10013

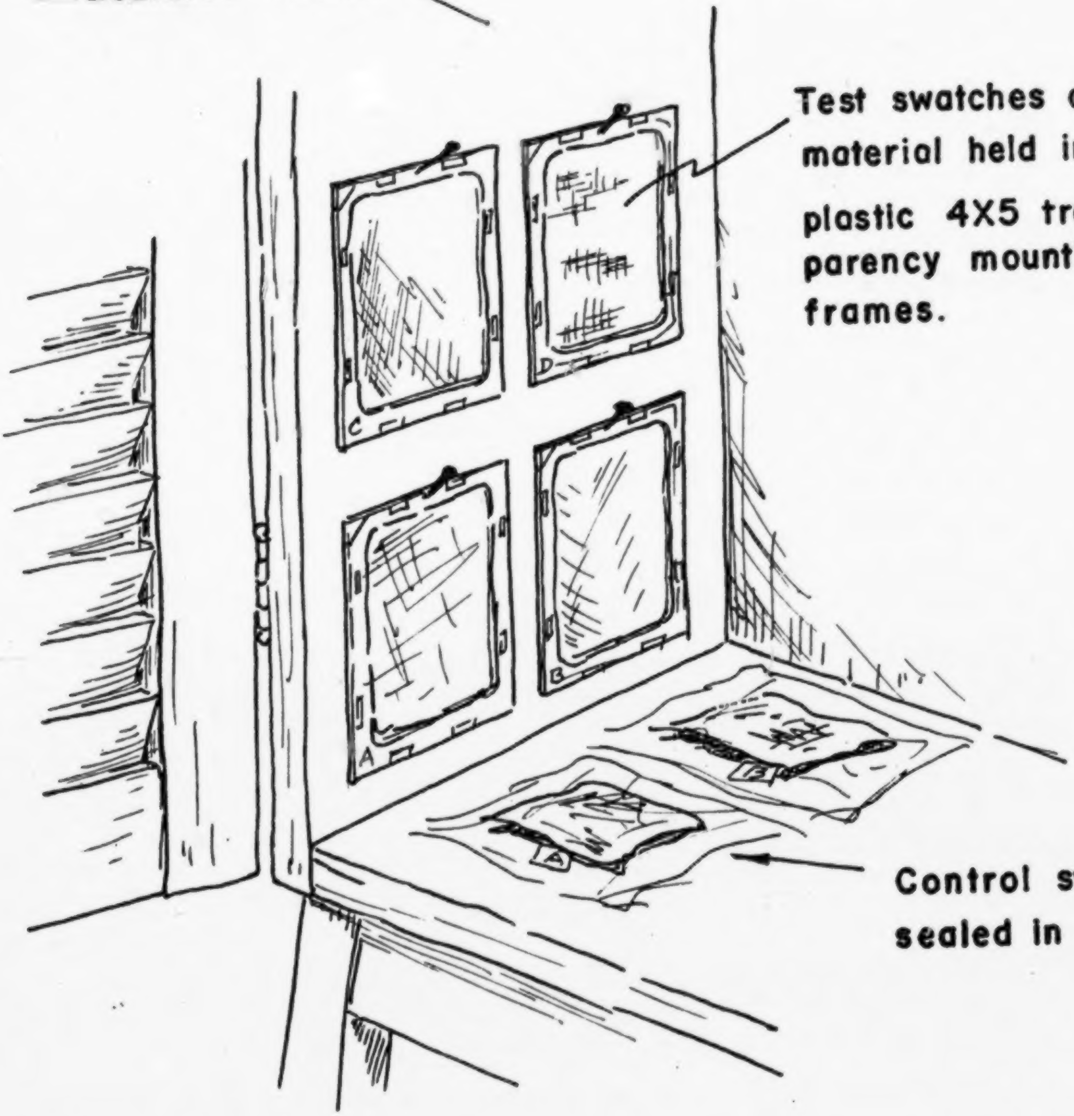
IV. Procedure

Make sure the nylon has no breaks in it before mounting. Cut the control fabric and nylon to fit the polaroid mounts; label and place the samples in the shelter. (See following diagram)

Clean the metals using acid and acetone if necessary. (Wash the sample with distilled water after cleaning.) Make sure that this is done in a hood and extreme caution is exercised by the student. After cleaning the metals find their mass. Place the metal samples on top of the shelter in an exposed location.

Leave all samples exposed for 90 days.

EFFECT OF AIR POLLUTANTS ON MATERIAL (B-13)



Louvered shelter

Test swatches of material held in plastic 4X5 transparency mounting frames.

Control swatches sealed in plastic.

D. Continued

V. Data and Results

1. Measure the reflectance of control cloth and metal samples to establish calibration curves.

2. Examine the nylon for breaks.

3. At the end of the 90 days, clean the metal samples of all corrosion and determine their mass deficit.

VI. Questions

1. From the mass loss of each type of metal, the cost per pound and the total tonnage of each metal used in the past year, what is the economic loss because of air pollution?

2. From the damage to nylon, what is the estimated yearly economic cost because of air pollution?

3. From a class opinion, what % reflectance would be allowed before cleaning a fabric was necessary? What is the economic loss because of required cleaning necessitated yearly by air pollution?

D. Continued

V. Data and Results

1. Measure the reflectance of control cloth and metal samples to establish calibration curves.

2. Examine the nylon for breaks.

3. At the end of the 90 days, clean the metal samples of all corrosion and determine their mass deficit.

VI. Questions

1. From the mass loss of each type of metal, the cost per pound and the total tonnage of each metal used in the past year, what is the economic loss because of air pollution?

2. From the damage to nylon, what is the estimated yearly economic cost because of air pollutin?

3. From a class opinion, what % reflectance would be allowed before cleaning a fabric was necessary? What is the economic loss because of required cleaning necessitated yearly by air pollution?

E. Insolation Depletion

I. Introduction

Very small particles scatter the insolation that we receive. By coagulation these particles may grow to large sizes and change their scattering properties. Very large numbers of small particles can deplete the insolation sufficiently to lower the earth's temperature over a very long period of time.

II. Objectives

1. To study the effect of insolation during various times of the day and at various seasons

2. To study the effect of particle size on scattering of light

III. Materials

photocell-milliameter radiation detector, clear polystyreene box with cover: 5 x 4 x 12 inches, one hole rubber stopper, 2 feet of tubing, light source, powder: lycopodium, aluminum, carbon, epoxy

Procedure

Cut a hole in the side of the box and insert the rubber stopper (or drill a hole and epoxy the glass tube to the box). Connect the rubber tubing to the stopper using a short piece of glass. Place the light source at one end of the box, and the radiation detector at the other end. Place the powder in the box and blow through the tube. Note the meter reading and relate this change to the size of the particles (see B-15). Try various powders and note their effect. (see following diagram)

The radiation detector may be set outside on a suitable flat surface and measurements taken during clear days as compared to hazy or cloudy, polluted days. A normal diurnal variation during clear days and cloudy days should be taken for a comparison standard.

V. Data and Results

1. Make up your own data and result tables.

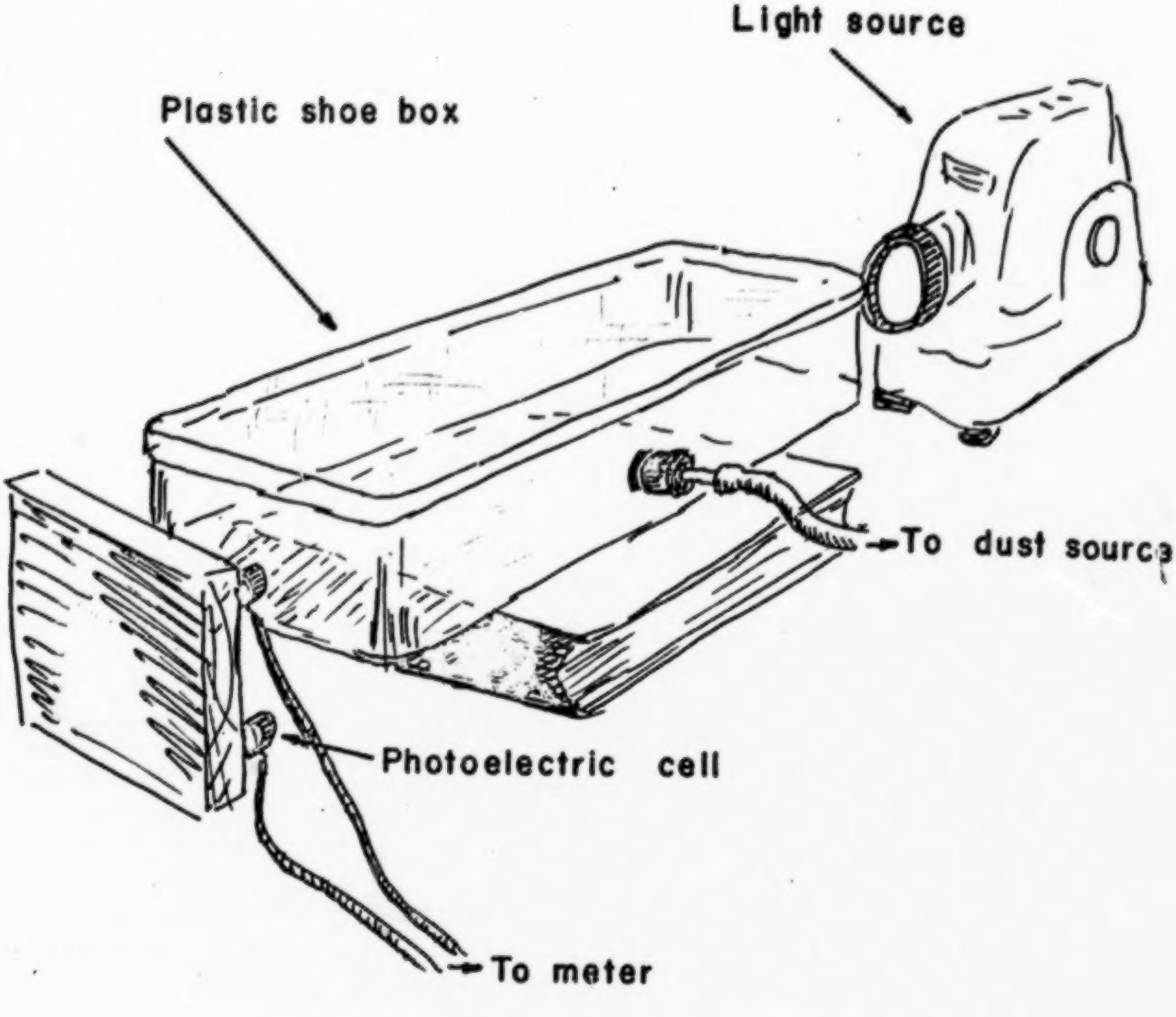
2. Enter appropriate data in the various tables.

VI. Questions

1. Which type of particle, light or dark, influences radiation the most?

INSOLATION DEPLETION

(B-13e)


Light source
Plastic shoe box
To dust source
Photoelectric cell
To meter

E. Continued

VI. Continued

2. Is the influence of particles radiation related to size?

3. Which particle, light or dark would cause a cooling effect of the earth's surface? Which particle would cause a warming effect of the earth's surface?

B-14 Testing the Radioactivity in the Atmosphere

I. Introduction

Nuclear testing above ground is capable of injecting radioactive particles into the troposphere and stratosphere. The particles can be scavenged from the atmosphere by precipitation and sedimentation. The radioactive particles removed from the atmosphere can enter man through the food chain. When radioactive nuclei are absorbed by particles which remain in suspension an inhalation hazard also exists.

II. Objectives

1. To detect radioactivity in the atmosphere

2. To measure atmospheric radioactive contaminents qualitatively

3. To explore the health hazard of radioactive particles in the atmosphere.

III. Materials

filter paper, Buchner funnel, vacuum pump, rain scavenging pollution detector, 300 speed Polaroid film pack

IV. Procedure

Collect a sample of particles on a piece of filter paper using the Buchner funnel technique previously used in exercise B-9. Radio= active particles so collected are detected by their effect on unexposed 3000 speed Polaroid film using the following steps:

1. Remove the film cover as if the camera were to be used normally.

2. Remove the pack from the camera in a dark room.

3. Place the filter paper in contact with the film and return film pack to the camera for a period of 2.5 hours.

4. Develop the film by the usual method.

5. Save the filter paper and make exposures after 24 hours and weekly for four weeks to determine decay note.

6. Count bright spots on film. What do these spots indicate?

7. Develop the next film in the pack. Is there evidence of exposure? How would you account for bright spots on the second film?

IV. Continued

Use the rain scavenging pollution detector (see next page) to collect particles. Dry the filter paper and follow the preceding detection method.

V. Data and Results

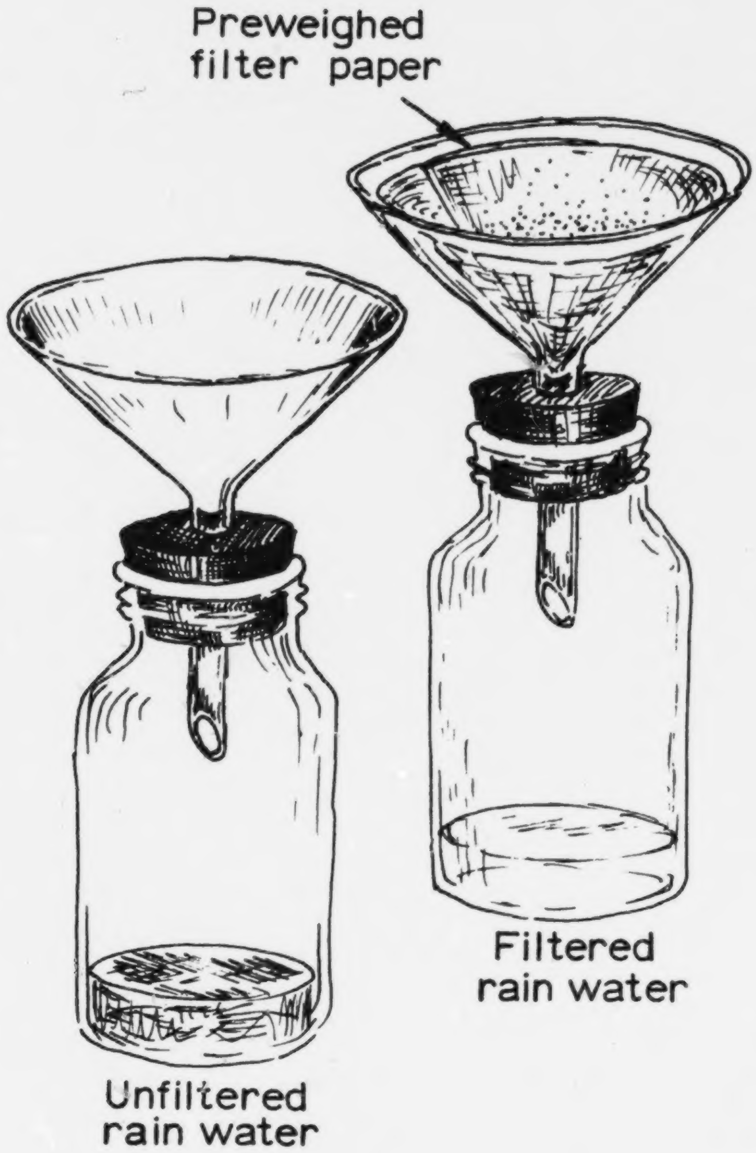
1. Report your data as short and long half life particles, the number of each and the number of each per unit volume.

VI. Questions

1. During which season do you notice more scavenging?

2. Do you find a greater incidence of radioactivity during violent thunder storm activity or during frontal passage?

RAIN SCAVENGING POLLUTION DETECTOR


Preweighed filter paper
Filtered rain water
Unfiltered rain water

B-15 Particulate Sizing

I. Introduction

Often it is useful to know the size distribution of a sample. The size distribution will give you some idea of the potential horizontal movement of the particles, the type of cleansing apparatus that would be most appropriate and in some instances, the source of the pollutant.

Sizes of irregular particles is considered to be diameter of a circle whose area is equal to the area of the particle. These diameters are most easily measured with a graticule placed in the microscope eyepiece. Most graticules consist of a series of circles or a combination of circles and rectangles. The diameter of a particle is that of the circle which appears to have an area closest to the projected area of the particle.

II. Objectives

1. To determine size distribution of a particulate sample

2. To indroduce students to representing statistical data and results

III. Materials

microscope slide, petroleum jelly, graticule, microscope, powder as a sample, (as an alternative see: Ward and Reynolds, "Simplified Airborn Solid Sampling" The Science Teacher, Vol 38 No 1 (Jan 1971).

IV. Procedure

Cover a clean slide lightly with the petroleum jelly and expose it to a dusting of the selected powder. The graticule may be calibrated by placing a scale divided into millimeters, on the stage. A 1 cm. to 1 mm. circle may be found and, from the diameter ratios given with the graticule, the sizes of the other circles determined. One student may size while the other student records the data. The students may periodically exchange positions until the entire slide has been sized.

V. Data and Results

After all of the data is taken it should be ordered into class boundaries (microns) and frequencies.

Class Member	Class Boundaries (microns)	Frequency Class Mark
1	0 - 1	0.5
2	1 - 2	1.5
3	2 - 3	2.5
4	3 - 4	3.5
5	4 - 5	4.5
6	5 - 6	5.5
7	6 - 7	6.5
8	7 - 8	7.5
9	8 - 9	8.5
10	9 - 10	9.5

A histogram may be plotted of no. of particles vs. particle diameter.

VI. Questions

1. What is the arithmetic mean for your data?

2. What is the mode? Median?

3. What are some methods of representing the spread of your data?

B-16 Analysis Using Sedimentation Foil Data
(*HYE Project)

I. Introduction

In many instances available data may be used to supplement an experiment or to replace an experiment where time and materials prohibit the actual experimentation. A further gain can be made when students analyze published data and extrapolate the data or infer conclusions from the data.

II. Objectives

1. To carry out an analysis of sedimentation foil data.
2. To extrapolate and infer conclusions from another person's data.

III. Materials

Data and charts included in this laboratory experiment.

IV. Procedure

1. Transfer foil data of tons per sq. mile per month to township map.
2. Locate areas of similar levels of pollution.
   One suggested technique:

Color Code	Pollution Level (Tons/sq.mi/month)
Red	over 16
Yellow	12 - 16
Green	9 - 12
White	less than 9

3. Add wind rose data from Schenectady and Albany County Airports for the sampling period to the map. Use a transparency overlay or trace onto township map.
4. Add topography data to the map or place transparency over the map; or trace in details.
5. If additional data can be noted or collected on the sites of industrial plants that have large stack effluents, place their locations on the map.

*Source - 5000 Join in Air Pollution Survey, by Dr. V. Mohnen, The Conservationist, Aug. - Sept., 1970.

IV. Questions

1. What relationships exist between pollution levels and prevailing wind, topography and industrial sources? Which has the greatest influence?

2. What are the ten most polluted areas and their pollution level; the ten least polluted areas?

3. Where would you choose to buy or build your home? What other factors must be considered?

4. How much pollution does home type heating contribute to the air as compared to industrial effluent? Does the map analysis give any indication? Compute the actual amount of mass on a typical 9.3 mg foil: 1) due to home heating; 2) due to industrial pollutants.

5. How would you expect the pollution levels to differ in summer, fall, winter?

6. Determine other ways to communicate with others the meaning or impact of the data collected (see sample computations).
   a) Convert mass increases on foils to tons; tons per square mile per month.
   b) How many railroad cars would be needed to move this air pollution sediment away from the sampling area? To where would you move it? How much would it cost?

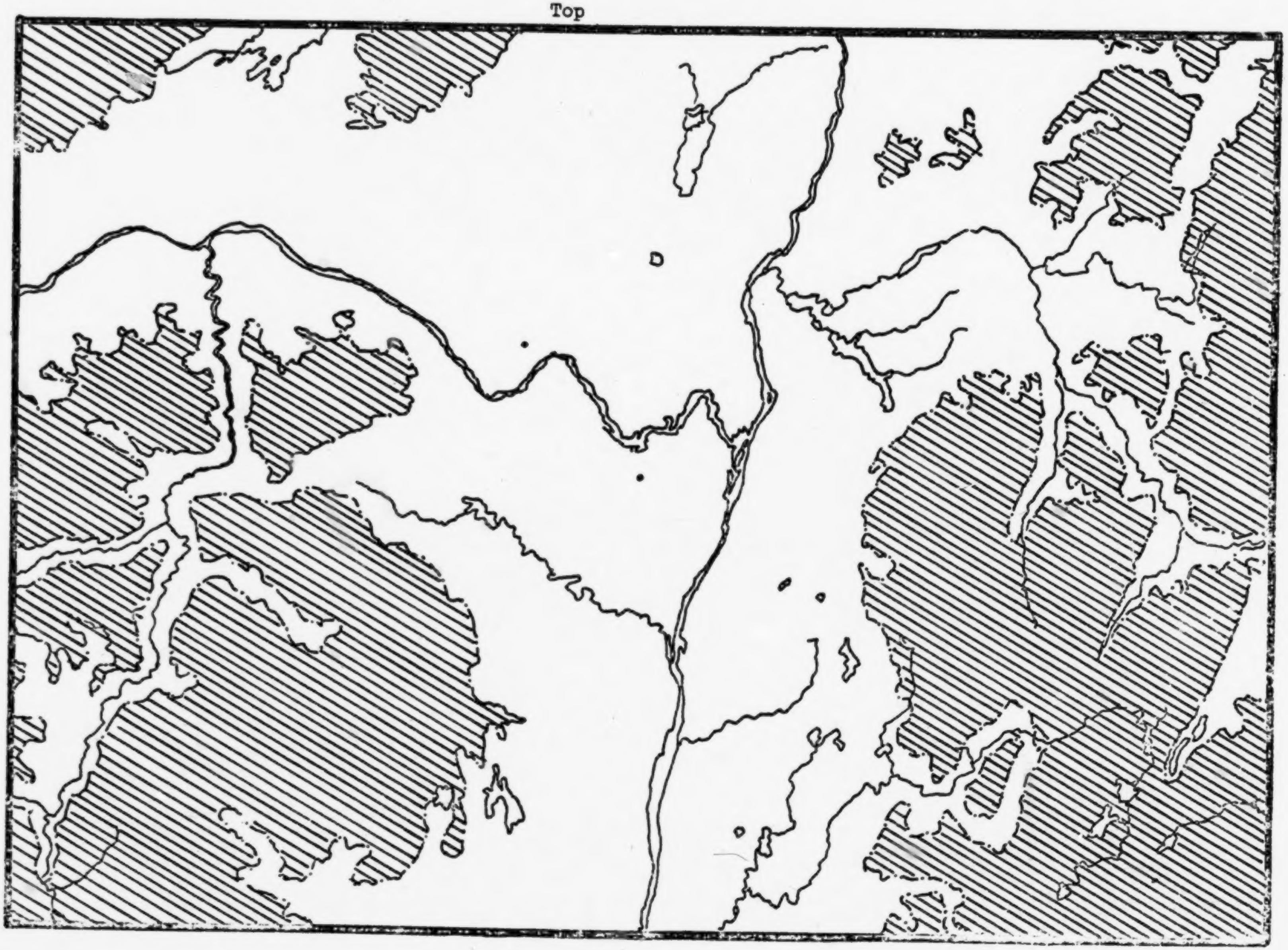
7. What size of particles found in the atmosphere does this technique measure? Why? What other particulates are present? Which sizes should we be most concerned about? Why?

8. If afterburners were added to the major stack effluent sources in the area, what would be the effect on the weight increases found in the foils? What does the afterburner do to the size of particles emitted from the stack? Does it reduce the total mass of material injected into the atmosphere?

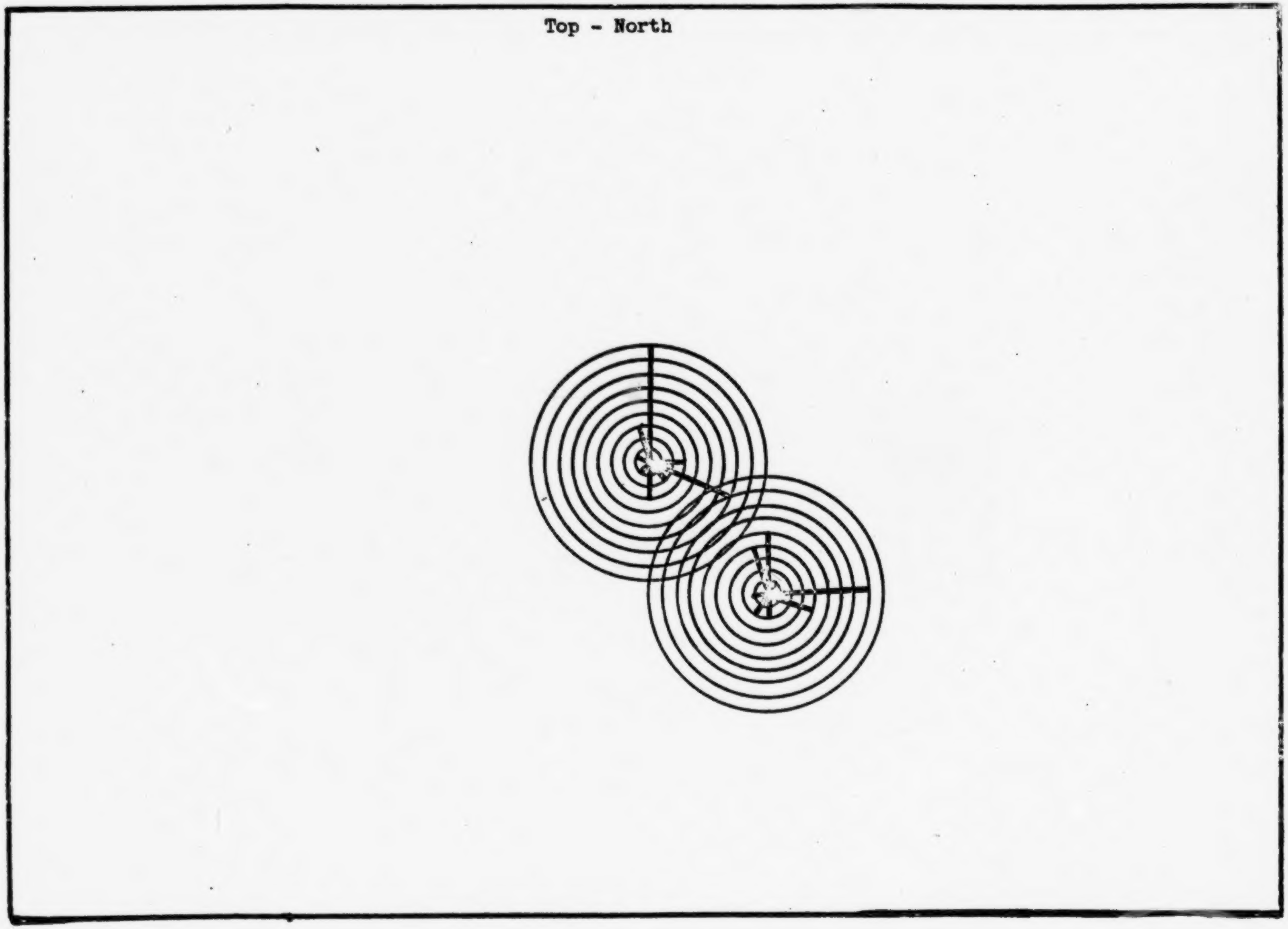
FOIL DATA

	Samples Located Within	Average Weight on Foils in milligrams (mg)	Average Dust Fall in tons per sq. mile per month
	Albany County	11.1	12.58
	Rensselaer County	8.2	9.29
	Saratoga County	7.2	8.15
	Schenectady County	9.3	10.51
10	Albany	12.7	14.39
12	Cohoes	11.7	13.22
	Watervliet	15.2	17.20
27	Bethlehem	7.9	8.95
	Coeymans	12.6	14.26
9	Colonie	11.7	13.22
11	Green Island	15.5	17.54
29	Guilderland	4.8	5.44
28	New Scotland	5.2	5.89
20	Troy	11.1	12.58
	Rennsalaer	10.9	12.33
19	Brunswick	4.9	5.54
22	East Greenbush	8.6	9.73
21	North Greenbush	5.4	6.11
23	Poestenkill	7.5	8.48
24	Sand Lake	5.8	6.56
17	Schaghticoke	7.6	8.60
25	Schodack	5.8	6.56
15	Mechanicville	10.2	11.54
2	Ballston	5.4	6.12
3	Charlton	4.2	4.75
7	**Clifton Park**	7.3	8.26
14	Halfmoon	10.6	12.00
1	Malta	7.6	8.60
16	Stillwater	5.8	6.57
13	Waterford	9.0	10.18
8	Schenectady	12.9	14.60
4	**Glenville**	6.2	7.02
30	Niskayuna	5.9	6.78
6	Princetown	6.1	6.91
5	**Rotterdam**	9.9	11.20
	Special Network	17.9	20.25
	Virgin Foil	1.0	1.13
	Outside Study Boundary	5.3	6.00

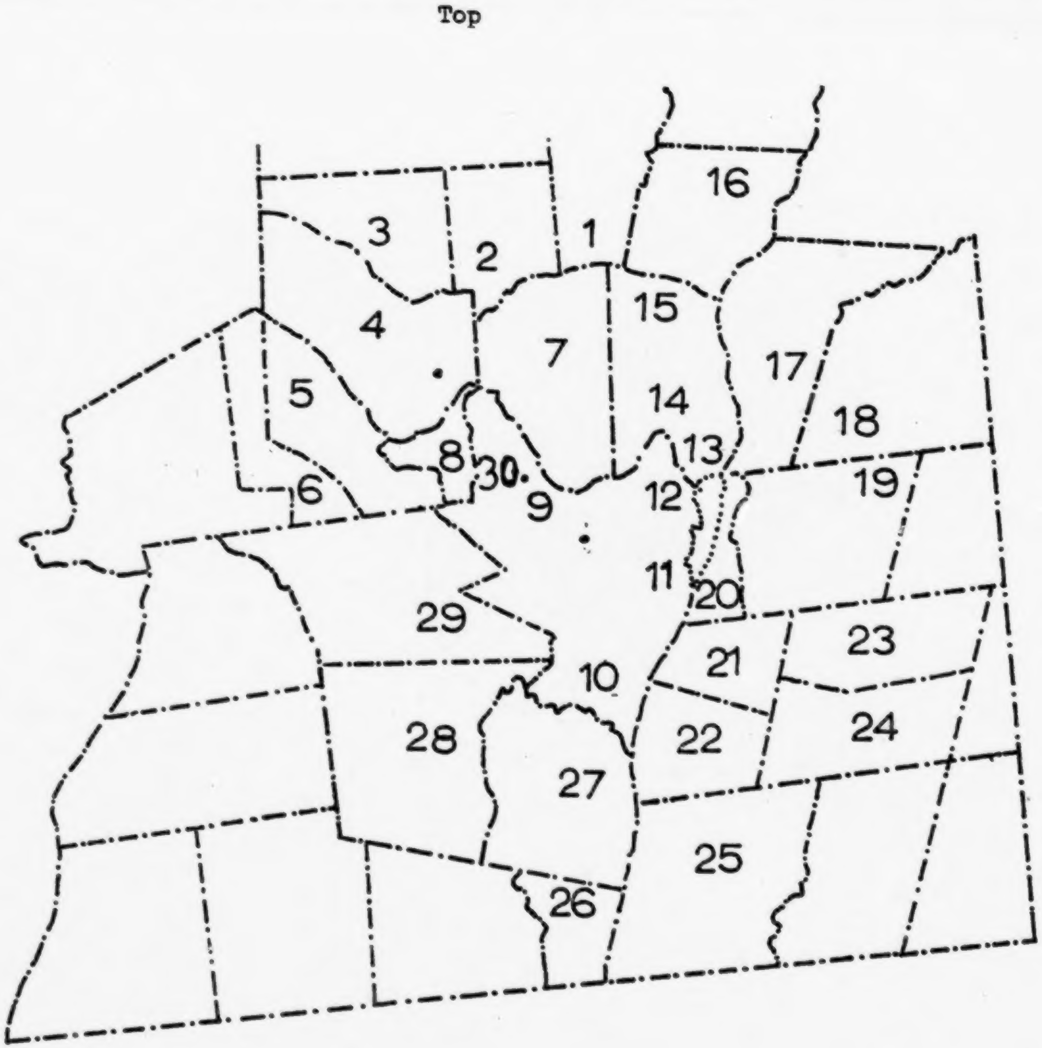
Topography Data (C-2)



Wind Rose Data (C-1)



Townshipmap (C-3)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C. Humanities Projects - Environmental Pollution and Literature

1. Use of a Poetry Unit in Environmental Studies
2. Model for Possible Unit in English for Teaching Some Ecological Considerations
3. Model for a Unit in Life Styles
4. Model for a Unit in Semantics and Environment: Language in Thought and Action, by S.I. Hayakawa
5. Model for Critical Reading Unit

C-1 Use of a Poetry Unit in Environmental Studies

Fire and Ice

--Robert Frost--

Some think the world will end in fire;
Some think in ice.
From what I've tasted of desire,
I hold with those who favor fire;
But if it had to perish twice,
I think I know enough of hate
To say that, for destruction, ice
Is also great
And would suffice.

The scientist came to our school and spoke at an assembly, telling us about air pollution. He pointed out that man and plants are interrelated in a neat little cycle in which man (and the other animals) inhale air and exhale (among other things) carbon dioxide, retaining oxygen for his own combustion purposes.

Plants, on the other hand, consume carbon dioxide in the process of photosynthesis, excluding oxygen which then is available for animals.

Plants, it was implied, could exist very happily without man (and the other animals), but man really needs that oxygen that the plants so cheerfully provide.

All of this interaction takes place in a gaseous mixture we call "air" which we tend to take for granted as something that is there, has always been there, and presumably will always be there. But what is this thing called "air?"

Mostly air turns out to be nitrogen which does not concern us here at the moment. Oxygen does concern us, and, if we take a sample of what someone claimed was clean, dry air gathered at sea level, we find that 20.9476% of it is oxygen. Carbon dioxide concerns our friends, the plants, the oxygen processors; their share of the air, the CO_2, comprises 0.0314% of the volume of clean, dry air gathered at sea level.

All well and good, and as long as man was content to confine his combustion activities to breathing, not much happened to affect this balance. But man is in love with combustion. From the moment his big brother Prometheus brought him fire, man has been burning something someplace: first, perhaps, for warmth; then, to prepare food or scare away sabre tooth tigers -- or both. Bye and bye he discovered that he could get his fires hot enough to melt certain rocks, and metallurgy was born, and so on to that ultimate in combustion, the age of technology.

The scientist pointed out that as a result of our enthusiasm for combustion we were throwing a lot more carbon dioxide into the atmosphere, than would have normally been occurring. Then he began to speculate on the implications of the increase of CO_2.

He postulated two possibilities. We could throw enough CO_2 in the air that it could absorb rather than reflect more of the sun's radiation. This could cause a gradual heating up of the atmosphere, which in turn could cause a gradual melting of glaciers, ice caps, and other frozen water repositories. Where would the water go? Ultimately to the oceans which, in turn, would rise, creating real estate problems on shore fronts, massive changes in harbors, and so on.

Reducing this to an absurdity, one envisions the Empire State Building be used as a mooring for the Queen Elizabeth, instead of for the Good Year Blimp.

Seriously, the geological changes which would ensue from such a catastrophe would create as much of a change as any of the great geological temperature shifts of the past.

But suppose, the scientist went on, that all the CO_2 did was create, along with other particulate matter, a shield through which less of the sun's radiant heat could pass? Suppose that what occurred was a great chill? ("Some think the world will end in fire, some think in ice.") Then we would go back to our next ice age that much sooner.

The scientist didn't come to any conclusion, but he left us with a lot to think about. We went back to the room and decided that having heard from the scientist, maybe we'd better get a reading on the problem from the poet.

"Some think the world will end in fire;"

But which fire? The slow burn of the excess carbon dioxide? The quick flash of the hydrogen bomb? The transcendent glory of our sun becoming a super-nova -- perhaps to be the Christmas star for some other planet in some other solar system in our galaxy?

And why fire, anyway? Frost says: "from what I've tasted of desire, I hold with those who favor fire." At first, that's sort of romantic -- burned out with passion, as it were. But is that the kind of desire that produces the fire that destroys the world? What desires do we have that destroy?

Well, there goes the rest of the period. Do not take more than one period to list the 1,942 desires of man that ultimately generate more combustion, and consequently more CO_2. After you and the class have listed a lot, you could group them into categories like transportation, industry, individual consumer desires and so on.

"...I think I know enough of hate
To say that, for destruction, ice
is also great..."

It's funny about hate. If you want to simplify (over simplify)? the state of the world, you can say that the hate that leads us to napalm, the ICBM, and the hydrogen bomb could lead to the destruction that Frost feels is a possibility. But you never see the word "hate" in a scientific journal. "Hate" is not a scientific word: in fact, even to mention it in a vaguely scientific context seems like bad taste.

Maybe that's part of the problem. Maybe we aren't going to work our way out of the "Fire and Ice" dilemma until the scientist is able to acknowledge that desire and hate are operative factors in the world, even if they are not subject to laboratory demonstration. And maybe the rest of us cannot learn to deal with desire and hate and their combustible by-products until we gain a little of the scientists' ability to measure and count and identify.

Perhaps, until we learn to blend what both the scientists and the humanists perceive as the way the world is, we will continue toward the destruction which is the subject of Frost's poem.

C-2 Model for Possible Unit in English For Teaching Some Ecological Considerations

Objectives: To teach social criticism through:
  a. satire
  b. discussion of implications of satire
  c. discussion of social action of various types

Materials: Kurt Vonnegut Jr., Cat's Cradle

Resources: Library, Av Department, outside speakers, etc.

Cat's Cradle is a novel which can be taught to bright tenth graders (honors level) and juniors and seniors. It can be called science-fiction, but we prefer to think of it as satire since it makes a strong social commentary on the irresponsibility of a certain type of thinking prevalent in our society -- maybe an irresponsibility that is part of man's "natural condition."

The central figure in the book is a scientist who enjoys pure science as a game (Cat's Cradle?) that he plays with life. His preoccupation with his game keeps him first of all from any normal father-child relationship that his children are all physically unusual or grotesque.

More important is the fact that he has invented or discovered a form of water which turns to ice at a relatively high temperature. This he calls "ice-nine." Ice-nine, we quickly learn, has the property of converting all water to ice-nine as soon as it comes into contact with normal water. Ultimately, we realize, that ice-nine could solidify the whole world.

Throughout the book we are aware that the scientist has no concern for the consequences of his discovery. He is merely amused by the cleverness of his discovery. Eventually, through ice-nine, the world as we know it is destroyed.

I. Teaching the Book

Since it is short, two or three days at the most is necessary for it to be read in. It would be well to read the first chapter out loud with the students to help them with any difficulties they have with Vonnegut's style. The main difficulty will be with the literal minded student. Probably a class session should be spent on the discussion of the ironic tone of the book, since it is through irony rather than direct statement that Vonnegut makes his points about social responsibility.

II. Discussion

Probably any discussion of the idea of the book should be postponed until the class has had a chance to read it clear through at least once.

II. Discussion (continued)

A. Discussion of the central character

1. What kind of person is he?

2. Do some people make such important contributions to our society that they should not be held accountable for normal social responsibility? (For students who have read Crime and Punishment this is the question Raskolnikov raised which leads him to commit his crime). See also "The Snow Queen" by Hans Christian Anderson.

3. Encourage the students to come up with their own examples of social irresponsibility. You will want to distinguish between the kind of irresponsibility that probably cannot be avoided because implications of an invention or innovation cannot be projected from exist-information, and the kind of irresponsibility which refuses to examine obvious problems that will probably arise.

Suggested examples:

a. McCormack and the reaper: This made it possible to exploit large areas of land. Originally, it was supposed to make it possible for one man to produce more from his efforts. One probably could not have projected dust bowls and insect problems from this invention which was to spare man from backbreaking labor.

b. The cotton gin: This had the effect of locking much of the South into a cotton economy which perpetuated slavery (leading ultimately to Black Power!), stripped the soil, etc.

c. Ford, automation, and the Five-dollar day. What did that do to the air!

d. Keep one. There are many more.

4. The problems created by social responsibility

a. Robert Oppenheimer and his desire not to work on the hydrogen bomb.

b. Harry Truman and the difficulties he faced in deciding to drop the atomic bomb on Hiroshima.

B. Warnings

1. To keep this responsible it might be well to assign reports. As different items of discussion come up, different students may research different items, according to their interest. The historically oriented

might research individual contributions -- cotton gin, etc. The literary types could explore suggested items of literature -- Jonathan Swift's "A Modest Proposal," etc.

2. The English teacher will not have the time to make herself cognizant of all the ecological implications or sociological implications. She (he) will find that social studies teachers, especially those versed in economics will be usefull as guest speakers or as idea sources for herself.

C. Political Action

1. This can be handled by the English teacher with a strong social studies background or in a team teaching situation with a social studies teacher.

2. Begin with discussion of social responsibility on the home level, school level, community level. Find out where your kids are in their thinking. If they're at the school level you can explore school problems. Example: One school we decided that it would help to shut down the school incinerator. A student committee discussed this with the principal. He got permission from central administration to shut down the incinerator for two weeks. This turned out to cost $12.00 a week for a "dumpster." Next year the same student committee is going to explore ways of cutting school waste. It has already gotten the office to publish the school absentee list and the school bulletin on both sides of one sheet, rather than on one side of two sheets. This saves a ream of paper a day or 180 reams a year. (What does a ream cost? How much do 180 pollute?)

3. If they're at the community level things open up. Examples: We brought in a sewer "expert" from the city who told us of the city sewer system and projected plans for its improvement. We learned about primary and secondary treatment. Later research by one student revealed that secondary treatment has its drawbacks. We began to learn about writing to government officials. We learned to understand how bills get through Congress or the State Legislature. We learned that we needed to read the daily paper (one student was assigned to clip pertinent legislative items from The New York Times and keep them in a vertical file for reference.) Class time was allowed for writing letters to legislators. Answers were posted on the bulletin board. We began to learn to make judgments about legislators from their voting records.

D. Social Action

1. Eventually we get into a discussion of life styles.

    a. Quality versus quantity
    b. The car as status symbol
    c. What happens to the economy if people start demanding quality? If they consume less goods?
    d. National parks, over-crowding, littering

2. What price clean air? (This must be open-ended. The teacher is there to expose options, to open up areas of thought, not to sell any particular way of life).

III. Back to Literature. Thoreau, anyone?

C-3 Model for a Unit in Life Styles

> Thank God men cannot as yet fly,
> and lay waste the sky as well as
> the earth.
>
> Henry David Thoreau
> (1817-1862)

Model for a unit in English or humanities. By examining two extremes in life style we hope to focus attention on the fact that varying life styles exist, that they produce varying side-effects, and that our involvement with our own life style is basically uncritical unless we take a look at it and learn to examine it.

In order to explore a variety of life-styles it might be useful to examine different concepts of what constitutes the Good Society. We frequently oppose our own American way, which we associate with "individualism," "free enterprise," and other such ideas, with the way chosen by countries which we describe as "collectivist," "communist," "socialist," or "totalitarian." Unfortunately, we tend to over-generalize with all these expressions, failing to see that several of these words contain concepts which may have qualities for both good and ill. We hope to avoid such confusion in this unit.

Walden by Henry David Thoreau is an extreme example of individualism carried to a limit. From it one can generate many questions about the advantages and disadvantages about individualism. Walden Two, on the other hand, is a description of a society in which the individual is accomodated as happily as possible to the needs of the total community. It is a "collective society, without necessarily being a totalitarian society.

Needless to say, one could use two other books or sources for a starter in getting students to examine the Good Society. We have included other titles, and suggestions for use, in the bibliography which accompanies this unit. We are not trying to give our version of the Good Society; we are merely trying to set up a situation in which good questions can be asked, and in which students can be led to begin to develop their own sense of what constitutes for them a good society.

Objectives:

1. To arrive at a definition of a Good Society.
2. To get some sense of the "Trade-offs" that we make, consciously or unconsciously, in order to arrive at an optimum life style for ourselves and for the community. Probably we need to explore how far we extend the concept of the community. Our town? Our state? Our nation? Our world?
3. To get a sense of how an unthinking choice of life style can produce side effects that may ultimately destroy the life style sought— or life, itself.

4. To involve the student very deeply. Many schools require a junior or senior essay, research paper, or the like. We propose that this unit be used as a junior or senior project, and that time in the curriculum be alloted for extensive searching.

   Such an involvement should be highly individualized. We envision a situation in which one student might be off in one direction preparing an annotated bibliography of twenty of the world's great Utopias, while another is working in close cooperation with the science department of the school, or with the engineering department of a nearby university on methods of producing housing through the use of rammed earth.

IF WE ARE GOING TO TRY TO TEACH STUDENTS THAT EVERYTHING IS INTERCONNECTED, WE ARE GOING TO HAVE TO LET THEM TAKE ON A WIDE RANGE OF PROJECTS TO INTERCONNECT.

Materials:

Class sets of Walden and Walden Two. Class sets of The Environmental Handbook and "Ecology: Making Peace with Nature and Each Other." Make assignments according to the level of your class. Few high school students can read Walden all the way through. We have found it best to assign the first two chapters, and then to let those who get hooked on Thoreau go ahead and read as much as they want.

Resources: Life Style Bibliography

If this unit is being taught for only a few weeks, single copies of these books in the classroom or in the library should be sufficient. If you plan to extend the unit to cover ten weeks or a semester, it would be well to have multiple copies of Language in Thought and Action, Siddhartha, Island, and The Subversive Science. Magazine articles are included, also.

Film strips: Another method of expanding this unit to a full course could be to use it in conjunction with The New York Times sound film strip series, "Crisis of the Environment." Each one of the film strips could be used to extend the time of the course for one to ten days, depending on how deeply one exploited the possibilities suggested by the film strip and the accompanying teachers' guide.

We have inserted into the study guide mention of the film strip at times where it might fit in. You may discover other ways to use the series which you feel are more fruitful.

Method:

I. We can think of *Walden* as explicating an individualistic life style; *Walden Two* unfolds a collectivist life style. A day could be spent on these two terms alone, since many of our decisions, political, economic and social, depend on our conscious or unconscious allegiance to one or the other point of view.

Briefly the individualistic concept of the good society can be summed up in the idea of everyone "doing his own thing." This is what we see in the "hippie" communes, but we also see it in laissey faire economic theory. It is certainly part of the American Mythology: all kinds of images come to mind: rugged individualism, "go West, young man," the "self-made man". It is an extremaly American point of view. It would be worth while to spend class time exploring this, and the different aspects of the culture that are suggested by it.

Certainly, in *Walden*, Thoreau is "doing his thing." Be sure that the students understand what the "thing" is that he is doing. He is not an adult boy-scout. Bear in mind his statement from his second chapter:

> I went to the woods because I wished to live deliberately, to front only the essential facts of life, and see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived. I did not wish to live what was not life, living is so dear; nor did I wish to practice resignation, unless it was quite necessary. I wanted to live deep and suck out all the marrow of life, to live so sturdily and Spartan-like as to put to rout all that was not life, to cut a broad swath and shave close, to drive life into a corner, and reduce it to its lowest terms, and, if it proved to be mean, why then to get the whole and genuine meanness of it, and publish its meanness to the world; or if it were sublime, to know it by experience, and be able to give a true account of it in my next excursion.

In order to do this, Thoreau stripped life activity down to what was needed to maintain his body heat. On this basis, he could then reintroduce to his life those other things beyond food, clothing, and shelter that he needed for his own gratification.

It is well worth the time to ask the students what the first thing is that they would add to their lives, as soon as minimal food, clothing and shelter had been provided. This might even be the subject of a short essay. "The first three things I want" sort of thing. Or, grouping the class into small committees, each committee could come up with its three things and present them to the class for discussion.

Out of these could grow an examination of the kinds of things wanted. No large generalities should be allowed ("a complete electrified house"). The magic three things have to be relatively specific: a car, a TV, a small personal library, materials to paint with, etc.

These discussions should be fairly productive. Perhaps it might be well to give the "my three thing" assignment both at the beginning and at the end of the total unit.

Implications of the "things" should be discussed. For example, if most of the class has a car or a motorcycle as one of its things, what implication does that have for the atmosphere? In other words, is it possible to do the things we want to do without impinging (infringing)? upon others' wants, rights, "things"?

At this point, if time and facilities permit, one might plan a field trip. A field trip is a highly individualistic thing. It should only be done by a teacher whose personal schedule is flexible enough to handle this kind of a disruption. The class should only be taken to a place that the teacher is already familiar with. Only interested teachers should be invited to co-chaperone. We shall describe one that we have done and one that we are contemplating.

A. On Earth Day two teachers guided a group of twenty-five students on a bicycle trip. Our destination was the State Capitol. We had several purposes:

1. To escort one of the students who was part of the Earth Day mock legislature.

2. To watch the governor sign the Environmental bill, and dedicate the Capitol's new bicycle rack.

3. To demonstrate that non-polluting transportation exists for relatively short distances.

This project required two teachers who were interested. One rode a bike; the other followed behind in a station wagon to pick up any casualties. It required a dittoed map of the projected route so we could find each other if we got separated. It required the usual permission slips and communications, letting parents, administrators, and the police of two counties know what we were doing.

B. We are planning a field trip to an area ten miles from our school, the Bozen Kill. This is an extremely lovely stream-waterfall-gorge-woods area which is currently threatened by an interstate highway. We hope to demonstrate to the students just what kind of thing has happened in the past, and will continue to happen with the indiscriminate planning of highways.

This trip needs to be thought of in terms of "Trade-offs" and other options. Do we need an extension of the highway badly enough to give up an irreplacable wilderness spot? Are more highways the only alternative to our transportation difficulties? What is involved socially, economically, politically, by increasing opportunity for private transportation? For public transportation?

At this point one could also introduce the first film strip in the New York Times series: "Man: An Endangered Species." One could merely show it and have a discussion, or one could expand it into a sub-unit, if time permitted.

II. Walden Two presents us with a projection of a collectivist concept of Good Society. Skinner puts forth a number of socially provocative ideas, based on his experiences as a behavioral psychologist. He presents his own **arguments** in favor of his theories; if you want an antidote, try the Measure of Man by Joseph Wood Krutch.

Walden Two is a small utopian society which is governed on the principles of social engineering. Behavior is directed by subjecting children to positive reinforcement of their good behavior. The book is placid and rational, making an honest attempt to imagine a society in which everyone wants to be well-behaved, in which all menial jobs are divided among everyone, and in which most community needs are provided by the community itself. It is rich in thought-provoking ideas for a "good society." It raises questions: Can human behavior be "engineered"? Would we want it to be, even if it were possible? What loses might we envision? How would Thoreau behave in Walden Two?

Here again we turn to the students. Again they could be led to individual essays, or to small group work after which they would present their findings to the class. What would be the benefits to the world of such a society? Is there really a loss of individuality in such a social structure? How much individuality should we surrender to make life a little nicer for the whole society? If we are properly "conditioned" a la Skinner, would we feel a loss to our individuality? Would such a loss be any greater than the losses **suffered by people** under our system as it exists? Who does what in our system?

III. **The Good** Society

A. Compile with the class (in small groups or altogether) a list of biological beatitudes.

1. It is better to be alive than dead.
2. It is better to be well than sick.
3. It is better to be nourished than hungry (to what extent?).
4. It is better to have a comfortable temperature surrounding us than to be too warm or cold.
5. Etc.

Expand these a lot. Ten? **Twenty?** Can the class assign relative **values to these? What order would they put them in?**

Film strip opportunity #2. This is a point at which one could use the second New York Times film strip: "Breaking the Biological Strand." The same opportunities for expansion exist as did before.

B. Try to arrive, with the class, at a definition of "Freedom." What distinction do they perceive between "freedom" and "liberty?" What response do they have to the following ideas?

1. Freedom is the capacity to act.
2. If we cannot be free socially, we cannot be free.
3. Liberty and freedom must be distinguished:
    a. Liberty is the removal of constraints.
    b. Freedom is the capacity to act.
4. The individual's liberty may have to be restricted to provide

freedom for all.

Use the essay, "The Tragedy of the Commons" in The Environmental Handbook, at this point. The class might compile a list of liberties we have already relinquished for the good of the group (the liberty of choosing our own speed in a residential district versus the freedom of the residents to not be killed by speeding cars).

5. Are the "demands" put forth on many campuses today demands for freedoms or for liberties? Are all such demands valid? How many if any encroach on anyone else's freedoms?

6. Another Film strip: Part III,"Vanishing Species" can be used as part of the exploration of the interplay between our desires and our encroachments.

C. Individualistic versus collective societies

1. If one of the things that the person in the individualistic society wants is a fast car, how does he go about getting it in a completely individualistic society? Does he build his own? How? Can there be such a thing as an automotive industry in such a society? Do corporations assume prerogatives of individuals in our society?

   How does the person in our present day society who wants to live like Thoreau go about getting pure air to breathe and pure water to drink?

2. If one of the things that the person in a collectivist society wants is a certain degree of individuality and non-conformity, how does he go about achieving it?

3. We think of the pioneer days in America as an individualistic, self-sufficient situation. If you didn't like the way things were, you could move on. (Turner Thesis?) On the other hand, we tend to think of collective societies as being akin to communism (Russian style) and to totalarian forms of government. This is not without some foundation. Certainly as we surrender some liberties for some public good, we are getting away from the pioneer dream.

   On the other hand, we seem to like our industrialized society -- or at least some aspects of it. Like what?

   Question: Can we have an interdependent industrial society, with its attendent goodies (cars, air conditioners, phonographs [sorry! stereos!]) without giving up some of our original liberties?

   Problem: How to strike a balance between the individualistic and the collectivist life styles.

   THIS WILL BE THE PROBLEM FOR THE REST OF YOUR LIFE.

And at this point we can once again introduce a film strip. Part IV, "Preserve and Protect."

4. At this point one might distribute class sets of "Four Changes" by Gary Snyder and of Allan Berube's "Ecology: Making Peace with Nature and Each Other." While these are relatively short papers, they are thought-provoking and raise many questions which the class needs to consider as it gropes for its definition of a Good Society. Plan to take at least a week in exploring the implications of these papers.

   Ask students to compile their own list of discussion questions from the two papers. One way of approaching this would be to suggest one list of things they definitely agree with, another of things they disagree with.

IV. What do we want and how do we go about getting it?

This is the point at which to launch people into their individual projects. An annotated bibliography could be distributed at this point for those who wish to read further. Various projects recommend themselves.

A. **The standard "paper":** This could take the form of an additional annotated bibliography, consisting of items which show an exploration in greater depth of any aspect of the whole picture -- like a list of readings in Utopian literature.

B. The preparation of a scenario or series of scenarios which project in dramatic form possible answers to the question "What if . . .?"

   1. What if we continue our population growth at present rates and our consumption of natural resources, with no restrictions on the use of air, land, and water as dumps for wastes?

   2. What if we ban the use of the internal combustion engine after 1975?

   3. What if we switch from fossil fuels as a power source to atomic energy and then discover that our computations about the radiation safety of atomic power plants were all wrong?

   4. What if we made a law that no private cars could be driven within the city limits of a city of 50,000 or over?

   5. A selected bibliography of science fiction has been appended. The works were selected because each one is a creative response to the question "What if . . .?"

C. Mock legislatures: These need to be preceded by some study of how legislation is generated. If possible, get a local legislator to come and talk to your class or to a group of classes. We have taken small groups of students to the State legislature to watch what goes on. At any rate, let them understand the concept of getting up a bill, the existence of various committees, exper testimony, etc. Then let them form their own legislature committees to identify problems in the society, to gather information about the problems, and to formulate legislation designed to eradicate or modify the problem.

Then, if you really want to live it up, get one class member to contact one or more legislators to see if it would be possible for the class committee to testify at a hearing on that type of legislation. This can be done; when it is done it is an unusually rich learning experience for the students involved. Obviously, it's only feasible if you live within a sensible distance from a legislative body.

D. Let one or more of the students use the last film strip in the series, Part V, "The Population Explosion," and develop a teaching plan on population for the whole class.

E. Creative writers might try re-writing the continuity for some of the film strips so that they could be used with elementary school children or with other classes. After writing the continuity, they could have a student who speaks well make a tape recording of the continuity to accompany the film strip.

F. Introduce students to items in either of the bibliographies. Let them report orally or in writing on one or more or the books. If each student has a copy of the list he will be able to mull over his choices.

G. Other: This is where your imagination and your resources take over. For example: If you happen to have a lot of camera freaks around, you may be able to do something with film. A good art department can produce things you never dreamed of.

If you are working on a team, each member should have a copy of the study guide. You may discover that different people see different possibilities. Pool your resources. Don't do it alone unless you're a real Renaissance man.

V. When it's all over, you might ask for a brief paper from each person: "The three things I want most, after the basic necessities, in the light of what I've learned in the last six (ten) weeks".

NOTE: See Section F - Appendix for Life Style Book List

C-4 Model for a Unit in
Semantics and the Environment

Objectives: To increase knowledge of some basic principles of communication. To apply these principles to environmental problems.

Materials: S.I. Hayakawa, *Language in Thought and Action*, New York, 1964.

Resources: Mass media

Semantics units may be taught in little or in big, modules depending on the nature of the class, the inclinations of the students, and the time available to the teacher. Let us assume that the teacher merely wants to teach enough semantics to sharpen students' critical reaction to information in text or advertising in television, radio, magazine and newspaper.

I. Preliminary Reading

A. *Language in Thought and Action*, Ch. 2 -- "Symbols." In this chapter Hayakawa describes the symbolic process. He quotes from Susanne Langer:

> This basic need, which certainly is obvious only in man, is the need of symbolization. The symbol-making function is one of man's primary activities like eating, looking, or moving about. It is the fundamental process of the mind, and goes on all the time.

Particularly important is his discussion of how pervasive the symbolic process is. For example: The female teacher reading this outline is going to be concerned in some measure this year with the distance of the hem of her skirt from the floor. Since such length has nothing to do with comfort and little to do with modesty, it is obvious that the question of the hem length is a symbolic one. Any way she wears her skirt will be some kind of symbolic statement. If she wears a "midi," she is fashion's slave. Is she keeps her skirts short, she is careless or indifferent.

For the purposes of this unit, the chapter gives enough understanding of the symbolic process so that we can understand how people can use symbols to influence our thinking.

B. *Language in Thought and Action*, Ch. 3 -- "Reports, Inferences, Judgments."

If you realy want to help your students clarify their thinking, this chapter will do about as much as any thinking in the field of humanities that we can think of. Hayakawa shows through lucid examples the difference between verifiable reporting, and the almost continuous inference and judgment making that we indulge in, under the illusion that we are thinking.

Again, the chapter provides semantic tools for examining information to which we are exposed, in order to test it against reality.

He touches on"slanting," the technique of using selected factual material to bring forth a specific reaction in the reader.

An interesting example of "slanting" can be shown if one were to make a collection of all the advertising that has appeared in the press in 1969 and 1970 about baby seals. The first ads appeared, sponsored by a save-the-baby-seal group. It displayed a pitiful looking baby seal, obviously torn from its mother. The advertising copy described the brutality of the means of killing baby seals: they were clobbered over the head and skinned alive in order that the pelt would be at optimum beauty. While the ad was "factual," it was also slanted, since words like "clubbed" when connected with baby anythings (except spiders) cause a profound reaction in many people, especially women.

Another interesting example of slanting can be found if you look up the ads prepared as a response to the outraged cry that went up from animal lovers, girl scouts, and grandmothers all over the United States and Canada. These ads employed the same technique: counter symbolism and counter slanting. To counter the over-powering symbol of the pathetic baby seal, they came up with the rugged pioneer symbol of the stalwart seal fisherman, braving the wilds of Northern Canada to eke out a precarious living. This ad's slanting consisted of a little ecology lesson in which we learned that, left to their own devices, seals breed indiscriminately, producing young that may starve to death or fall prey to sharks. How much more merciful to give the quick tap on the head, freeing the baby seal from the perils of arctic life.

II. Discussion and Activity

A. These must be intertwined as activity should lead to discussion and discussion to activity.

B. In connection with reading: Be sure that the students have worked through the exercises in Language in Thought and Action. Devote some discussion to these exercises until everyone is able to handle the vocabulary.

C. Have the students start their own collections of semantically interesting events in the media.

D. Social Science Projects - Environmental Pollution and Social Science Disciplines

1. A Sample Approach to the Problem of Air Pollution
2. Model for a Unit on Human Values: Bigger is Better
3. Societal Problems for Class Discussions
    a. Social Implications of Transporation Problems
    b. Model for a Unit on Individualism
    c. Model for a Unit on the Industrial Revolution
    d. Model for a Unit on Legislation
    e. Model for a Unit on Societal Ecology

C-5 Model for Critical Reading Unit

Objective: To improve critical reading of expository material by examination of the voice and tone of such material.

Method: Examination of three essays relating in one way or another to atomic radiation. Specific attention is paid (1) to the qualification of the authors, (2) the tone of each essay, and (3) the voice of each essay.

Materials: Gofman, John W. and Arthur R. Tamplin, "Radiation: The Invisible Casualties," Environment 12:12-19, 40, April, 1970.
Rapoport, Roger, "Catch 24,400 (or, Plutonium Is My Favorite Element)" Ramparts, pp. 16-21, May, 1970.
Seaborg, Glenn T., "The Environment: What To Do About It" Vital Speeches of The Day, XXXV: 514-520, June, 1969.

I. The Men - In arriving at an informed opinion, the student needs to know who is talking or writing, what his qualifications are for discussing the subject, what his possible bias is likely to be. How do we go about getting this information? Does Who's Who, for example, give us all we want to know about such people?

A. John W. Gofman - formerly Associate Director of the Biomedical Division of the U.S. Atomic Energy Commission's Lawrence Radiation Laboratory at Livermore, California. Now Professor of Medical Physics at the University of California, Berkeley.

B. Roger Rapoport - free-lance journalist and co-author with L.J. Kirshbaum of Is The Library Burning? He was editor of the student newspaper at the University of Michigan.

C. Glenn T. Seaborg - Chairman, U.S. Atomic Energy Commission. His speech was delivered at a meeting of the National Academy of Sciences Panel, Argonne National Laboratory, Argonne, Illinois May 5, 1969.

D. Arthur R. Tamplin - Research Associate at the Lawrence Radiation laboratory at Livermore, California.

The above, the student discovers, is minimal information. Except for Rapoport, the authros work in the field of atomic energy. We may assume that they are competent enough in their field to continue to be hired in that field. Since there is a difference of opinion between Seaborg on one hand and Gofman and Tamplin on the other, a difference which Rapoport uses as the focus of his essay in Ramparts, we need to know more. Why do we need to know more? Because the three articles deal with the question of allowable radiation in the environment. One of the potential sources of electric energy is the nuclear power plant. If we have nuclear power plants what risks are we running from possible contamination of the atmosphere or the total environment?

Eventually, we come to the question: How much do we care? If we really don't care about what radioactivity does to us or might do to us, we can settle for the information we already have. But suppose we really feel that the solution to the problem of power generation lies in development of the nuclear power plant. Then we will find ourselves trying to support Seaborg, to refute Gofman and Tamplin, and to disparage Rapoport. If on the otherhand we are worried over the degree to which radiation can increase cancer or cause us to have two-headed grandchildren, we will find ourselves trying to refute Seabor, support Gofman and Tamplin, and extol Rapoport.

Either way, if we are interested, we need to do three things:

1. Find out more about atomic radiation:
    a. learn some basic vocabulary
    b. learn some basic concepts of radiation and atomic energy
    c. learn something about the link between radiation and disease.
2. Find out more about the four authors.
3. Read the articles carefully and critically.

The physics teacher or the encyclopedia can help us with the first. We can find out more about the authors through *Who's Who*, *The Readers' Guide to Periodical Literature*, and *The New York Times Index*.

The third item requires development of ciritcal reading skills. Understanding of two rhetorical principles, *tome* and *voice*, will help develop skill in "reading between the lines" or getting at the author's point of view or bias.

II. *Tone* in the articles. Tone is the way in which the author uses vocabulary in order to show his attitude toward the information he is dealing with. Since tone can work to influence the reader through word choice rather than information the student must learn to recognize it.

A. *Tone* in the Gofman article. This is the most objective of the three articles. The tone is reasonable. The material is presented in a logical organization; it is carefully limited to deal only with one aspect of radiation damage: cancer. This limitation enables the authors to go into some depth and detail to expose their argument. The tone of the sixth paragraph, however, gives us some insight into the authors' point of view.

Quotation:

> The Federal Radiation Council, which sets the allowable peacetime radiation standards, has access to the information by which we have arrived at the above conclusions. The present standard, if allowed to stand, must be understood to mean that the government is willing to *trade off** thousands of cases of cancer and leukemia in return for peaceful atomic energy activities.

*italics by svs

For our study of tone, the most important expression in the paragraph is "trade off" in the second sentence. Colloquially "trade off" means to accept an acknowledged loss in expectation of a greater gain. This may very well be what the government is doing; however, the word "trade off" which is commonly applied to the inanimate, in this case implies a callousness or inhumanity on the part of the Federal Radiation Council.

Exercise:

A. Rewrite the second sentence to eliminate the affective connotation of "trade off." Rewrite it to make the FRC look warmly concerned with human problems.

B. Tone in the Rapoport article. The tone-sensitive reader can have a field day with this one. The title itself sets the tone: "Catch 24,400 (or, Plutonium Is My Favorite Element.)"

1. Title
    - a. "Catch 24,400" is an allusion to Catch 22, an ironic, anti-war novel.
    - b. "24,400" is the half-life of plutonium.
    - c. "Plutonium Is My Favorite Element," is a quotation attributed to Dr. Wright Langham, an AEC plutonium expert at Los Alamos.
    - d. What is the effect on the reader of using this title instead of "Certain Questions about the Atomic Energy Commission's Self-Regulating Powers"?

2. Examples of maintenance of tone through verb choices
    - a. Par 13 "cloak-and-dagger air"
    - b. Par 14 "background radiation is a favorite AEC game"
    - c. Par 14 "the organization's . . . nuclear mythology"
    - d. Par 18 "AEC totalitarianism"

4. Etc. Suggested activities
    - a. Each student can compile his own list of "loaded" words.
    - b. An exercise in denotation and connotation leading to a study of Rapoport's "loaded" words. Can the student see how many of these word choices represent judgments rather than facts or inferences?
    - c. Each student could write an assessment of Rapoport's personal bias as the student infers it from the article. This should be brief and should be supported by examples of Rapoport's word choices.

C. Tone in the Seaborg Speech.

Seaborg achieves his tone partly through word choice but even more by arranging historical and contemporary information in a way to suggest that there have been problems before, there are of course, problems now, but wise good men are working on the problems and things will work themselves out.

1. Soothing expressions
    - a. Par. 1 "More is being done today . . . harmonious relationship."
    - b. Par. 2 ". . . calmly attempting . . . perspective."
    - c. Par. 3 ". . . a building hysteria . . . should be tempered . . . rational outlook . . ."

2. Historical references
    - a. Par 8 catalog of famous natural disasters
    - b. Par 13 antiquity of air pollution legislation
    - c. Par 15 the horse, cities, and air pollution

3. Wise and good men are working
    - a. Par 24 Dr. Abel Wolman
    - b. Par 28 "President Nixon's great concern . . ."
    - c. Par 48 Dr. Gerald F. Tape

4. Etc. Suggested activities
    - a. Let the student compile a list of expressions from the speech that are soothing or relaxing. The beginning of the speech is studded with topical allusions and colloquialisms.
      How do these work to establish the tone of concerned equanimity?

    - b. Let the student think of why, when Seaborg's field is atomic energy, he does not mention atomics or radiation until paragraph 41? On the other hand, since his title is "The Environment: What to do About It," why does he devote 25 paragraphs of a 67 paragraph speech to nuclear energy?

III. Voice in the articles. Voice is what we call the author's language usage as it reveals his attitude toward his audience.

A. Voice in Gofman and Tamplin. The very absence of affective language provides a voice. The objectivity and careful, precise logic presupposes an audience who prides itself on objectivity and rational discourse.

1. The student might count the colloquial expressions and plot their distribution. They are not evenly distributed. What purpose do they serve? What is achieved by locating the bulk of them where they are?

2. Dr. Seaborg devotes a fair amount of space to "what might seem a new era of nature worship." (paragraph 4)

    a. Par.4 ". . . an ardent hiker and nature-lover myself. . ."
    b. Par 4 ". . . technology has made nature accessible to us as a friend to be understood. . . rather than a foe to be over come."
    c. Par 4 "The new conservationist. . . 'roughs it' on his own terms with . . . 'store bought' items . . . But he . . . forgets . . . this in his attacks on his technological society." Question: is the conservationist who attacks the technological society necessarily the same man who goes camping in a $3,000 camper?

    d. Par 7 ". . . nature plays no favorites."
    e. Par 8 ". . . nature destroys and pollutes-"
    f. Par 20". . . the well-meaning concern and dedication of the conservationist and nature enthusiast. . ."

3. Although Dr. Seaborg eventually arrives at a point where he suggests that a balance can be reached between ecologists and technologists, he has been at some length faintly disparaging the naturel-oriented point of view. Considering his audience, why might he be doing this? What does his audience have as their primary interest?

D. Activity

1. Since the Gofman-Tamplin article and the Ramparts article both express alarm over atomic radiation, the student might write a brief compare-constrast paragraph discussing the audience implied by the voice of each article, using examples.

2. Discuss orally or in a paragraph the purpose of each of the articles as implied by their voice and tone. A good approach to this is to name the magazines to which you as agent would try to sell the articles. How would each article have to be changed to make it acceptable to The Atlantic Monthly? Mademoiselle? Life? The Conservationist? Fortune?

This last activity is important and can be a lot of fun. Students who write fairly well enjoy parodying and can learn from rewriting key paragraphs to slant them for different publications.

IV. Further adventures - if the teacher finds an increased concern over the manipulative aspects of language, we recommend a short course in semantics - or at least an introduction to Language in Thought and Action by S.I. Hayakawa.

D-1 A Sample Approach to the Problem of Air Pollution

Who Owns the Air?

Objectives:

1. To understand that part of the problem of air pollution lies in the treating of air as a free good.
2. To understand through a discussion of this idea that a solution to the problem may lie in restricting everyone's individual liberty to provide freedom for all.
3. To understand that there are many factors that make this solution a difficult one.

Materials:

1. Accounts of the various air disasters in the 20th century (London, New York, the Meuse Valley in Belgium, Donora in Pennsylvania, New York City) see bibliography.
2. Reading "The Tragedy of the Commons," by Gilbert Hardin in The Environmental Handbook.

I. The problem of air pollution can be established by a reading of one or more of the accounts of the various 20th century air disasters. These accounts are available in many forms, one or more of which will be suitable for the level of students you are dealing with. The entire class could read more than one account or groups of students can be assigned to read a particular account and summarize it for the class.

  A. After these accounts have been read, class should try to arrive at the common aspects of each:
    1. What happened in each disaster?
    2. What did these particular areas have in common?
    3. What specific factors account for the extreme effects in these cases?

  B. Even though these disasters are extreme examples, what factors that contributed in each of these are not limited to these needs alone? The idea should be brought out here that certain activities of man contribute to air pollution - the more obvious ones industrialization, increasing urbanization. Discussion should also bring out that even such activities as certain farmingpractices (spraying, use of fertilizers, deforestation), individual activities (driving a car, burning trash, increasing demands for electricity) contribute to conditions of air pollution.

II. Reading of Gilbert Hardin's "Tragedy of the Commons": This reading may be rather difficult for some students, in which case it could be exerpted or simplified. Another possibility lies in using just the example of the herdsmen and the common pasture. The ideas of the article are specifically related to population growth but they can be applied to the treatment of the air.

How has the air been treated as a commons?

What individual benefits have been derived from this?

How would you react if someone offered to buy the air around your house? If you were to take the idea seriously, what problems would you fact? (here the idea of difficulty of deciding exactly what portion of air is "yours" and difficulty of assigning a price to the air).

Is it true to say that since everyone owns the air, no one in particular is responsible for it and its use poses no cost to anyone?

Is the pollution of the air really a free activity? (possibly free to the immediate polluter, but what costs are there involved?- health costs, aesthetic costs, property costs, etc.) If there are costs, who ultimately pays them? Who should pay? (only the polluter or everyone who shares the benefits of clean air?)

The idea of social or external costs could be introduced here - the difficulty of measuring them, the difficulty in pinpointing the exact source.

III. Ways of making the polluter bear the cost of his pollution:

This can be handled in several ways - independent or group investigations, outside speaker, use and collection of current news articles (assigning students to clip pertinent articles during the course of the units is a good idea whatever approach to this is chosen).

Briefly summarized, the means of making the polluter assume the cost of his pollution fall roughly into 3 areas:

1. Internalizing costs - most common in this area are effluent or emission fees, requiring the addition of pollution control equipment in new or existing plants in industry; requiring the installation of pollution controls on autombiles - these costs generally passed on to consumer in form of higher prices.

2. External costs - use of public monies (taxes) to pay the cost of preventing, controlling or rectifying the damages caused by pollution. Examples here in industry would be subsidies, tax write-offs for pollution control equipment, better depreciation allowances etc. - These costs are borne collectively through higher taxes.

3. Sanctions - outright prohibition of certain activities.

Investigation of the various ways of making the polluter bear the cost of his pollution could involve group or independent study of the following:

1. Most students, as do most people today, probably assume that, in talking about the "polluter" being forced to pay the cost of his pollution, reference is being made solely to industry. A student or group of students could search out information concerning the actual percentage of sources of air pollution. What individual or community activities are responsible for large amounts of air pollution? What ways can they recommend to curtail this? What would be the effect of control of these individual or community activities?

2. A survey could be conducted in the community to determine peoples' attitudes toward air pollution - what do they see as the main sources of the problem, (individual activities, industrial activities, governmental activities); how do they feel that solutions might best be handled, what restrictions would they be willing to accept in order to improve the situation, would they be willing to pay for improvement through higher prices, higher taxes, etc.

3. Is the electric car the answer to the automobile and air pollution? An investigation could be made of the effects of an electric car - is it feasible, what would be the effects, for example, on the oil industry and service stations, on air pollution from increased electric generation?

4. The Pittsburgh situation - why were business and banking interests so concerned about Pittsburgh being known as the "smoke city?" What did they do about it and how did they go about solving their smoke problem?

5. A study of effluent fees - How will business react? Will politics play a role in administering the fees? How many fees discriminate against small firms? How could the fees become a "license to pollute?" Can effective monitoring and detection systems be established? Will the fees be a sufficient incentive to reduce pollution? (A good discussion of, and approach to, effluent fees is a leaflet published by the Joint Council on Economic Education: "The Economics of Pollution, Part III, Can Pollution be Controlled?" by Harold Wolozin).

6. Air Pollution control in Los Angeles - What is the background of the various air pollution control laws in this community? How did community consciousness lead to a partial solution? Even though industrial pollution is fairly well controlled, what still accounts for the severeness of the

situation there? (A good starting point for the L.A. story is the October 8, 1966 issue of Saturday Evening Post, the story on air pollution).

7. The possibility of a pollution tax - a tax (similar in idea to industrial effluent fees) to be paid by the consumer of an article that contributes to pollution - a car, disposable cans or bottles, gasoline, etc. Money from the tax would be used to pay the cost of the pollution that the use of the article creates. What difficulties are involved in this? What effects would this have?

8. A case study of the internal and external costs of the manufacture of a particular article - for example, the automobile. This could be used for several items:

   - list the costs involved in the manufacture of an automobile that are figured into the cost of production. Why are these called "internal costs?"

   - what external costs are there involved in the production of an automobile? (the pollution involved in the various processes involved in the production of the components of the car - the steel, the glass, etc.).

   - what external costs are there involved in the use of the car?

   - who pays the costs?

   - what are some possible ways of internalizing these external costs?

D-2 Model for a Unit on Human Values

Bigger is Better

Model for possible unit in Humanities (or Science) using folk tales as a source for examining some human assumptions which relate to how we treat our environment.

Bear in mind that such a study guide is an example of how an English teacher can use basic literary material to encourage Environmental Awareness. By all means use your own favorite materials to work toward the same ends.

Objectives:

1. To use traditional folklore of the western world to show how folklore reflects values and assumptions of a culture.
2. To examine some of these values and assumptions to see how they might have contributed to some of our contemporary environmental problems.

Materials:

Prometheus, The Sorcerer's Apprentice, The Fisherman and his wife. All of these are available in a variety of anthologies and children's collections. The individual teacher will decide what kind of translation he wants for his own purposes.

Resources:

Library, AV Department. A Disney version of "The Sorcerer's Apprentice" is part of the film Fantasia. Illustrated children's editions can be found in the children's room of most public libraries.

Synopses:

Prometheus was the Titan who defied the Gods and brought fire to man. For this he was punished by being chained to a rock where he was daily attacked by eagles. His sister-in-law was Pandora who opened the box containing all the world's evils plus Hope.

"The Sorcerer's Apprentice," is the story of the boy, apprenticed to a sorcerer, whose job is to sweep out the house and carry heavy buckets of water. When the sorcerer goes out, the boy uses an enchantment he has learned to bring the broom to life so that it will carry water for him. The broom does come to life and immediately starts carrying the water. Unfortunately the boy does not know how to stop the broom. It continues to carry water until the house is flooded. Eventually the sorcerer returns and restores order.

The Fisherman and his Wife: The poor fisherman and his wife live in a hovel by the sea. The fisherman catches a flounder who persuades him to let him go in return for a wish. Consulting his wife, the fisherman asks for a pleasant **small** house and receives it. However, the dissatisfied wife sends the fisherman back to the fish for a castle, then a king's palace, and so on. Each wish is granted until the woman asks for the power to rule the sun and the moon. Then the fisherman returns from the shore to find his wife back in the original hovel.

A Note on Teaching:

The three stories could be taught all at once. The teacher could assign all three stories to be read overnight. This means he would have to have duplicated classroom sets of each story. The class could then be divided into three groups, each of which would have one of the stories to study.

Alternatively, the teacher could read each story aloud, or use a film or available recording, on successive days, then work in discussion with the whole class on each item.

Either way certain discussions points will emerge; certain opportunities for independent study will arise.

I. Prometheus

A. Discussion

1. What does fire represent?
    a. good aspects
        1. warmth
        2. cooking
        3. metal-working
        4. ultimately it symbolizes the opportunity for technology - air pollution

    b. bad aspects - can't you work out your own!

2. (Very hard question - attack it from different angles). Why did the Gods punish Prometheus? Or, why did the Greeks have the story come out that way? What statement does this possibly make about man's feelings about fire and the power for good or evil represented by fire?

3. Since the fire represents energy, does this story reflect any unconscious reservations about the risks man runs when he pokes around with nature?

4. Is there any significance to the fact that a companion myth shows Prometheus' sister-in-law, Pandora, having an irresistible urge to open the box which, it turns out, contains all the evils of the world? It also turns out that the box contains Hope. Again, what are the Greeks trying to tell us?

Any parallels between stealing the fire and opening the box?

5. Surely there are more questions.

6. How many Prometheuses have there been? (okay - not many big ones, but how about the little ones?) List a number of inventions and discoveries that have been double-edged with vast potential for both good and ill. Are there any important inventions that don't have such potential. Now tie this all in with air pollution.

B. Activities

1. These can pretty much depend on the level of your class, and the interests of the students. The list generated by A 6 could be used as a basis for individual reports on particular inventors and inventions. For the purposes of this unit it would be well to ask each student investigator to wind up with a statement of his inventor's contribution to air pollution.

   Place emphasis on the fact that we are beginning to bring the conscious level what the collective unconscious seems to have been aware of for a long time. Our purpose is not to decry invention, but to become environmentally aware enough that we think of environmental consequences far more than we ever have before.

2. If this is a humanities unit one could at this point or at the end of the whole unit use the Encyclopedia Brittanica film Oedipus the King which explores some of these questions.

   Slides of Greek Art, statuary, pottery, and architecture can be used. Get your Art History teacher in on this one.

II. "The Sorcerer's Apprentice"

A. Discussion

1. Since the moral of this story is not going to be too hard to dig out, especially after you have been through the discussion of Prometheus, we suggest you divide the class into small groups, appointing a recorded in each group, and let them do their own discussion.

2. Small group work goes better with some direction, so each group could be charged with coming up with its own answers to the following:
   a. Using the characters in "The Sorcerer's Apprentice" as symbols, what would you say that each represented?
      1. The apprentice
      2. The broom
      3. The flood of water
      4. The sorcerer

b. Can you draw analogies between the folktale and contemporary technological civilization?

c. Do you feel that the interpretation that we make of the story today is the same that a person of the eighteenth or nineteenth century would have made? (In other words, teacher, on one level this is merely a story about what happens to lazy, disobedient children; on our level it is more ominous--or is Man merely a lazy, disobedient child?)

B. Activity

1. Reports from your discussion groups. If these turn out to be good they may suggest a whole mess of topics that we haven't even thought of. In that case, follow through on what the students come up with -- at least for a while.

2. Ask people to watch in the public press, media, etc., for use of expressions like "...if we open this Pandora's box," and bring in any such allusions that they find. Editorial pages are a great source for this type of rhetoric.

3. If your school is rich, try to rent Disney's Fantasia. It contains a "Sorcerer's Apprentice" sequence, plus a lot of other items you could use happily in a humanities course, unless you can't stand Disney.

III. The Fisherman and His Wife

A. Discussion:
Whole group or small group according to your personal style. Mainly the question in this case is the insatiable person. This should lead quickly to consideration of the question of whether it ever possible to give men everything they want.

This can lead to an exploration of the question: Why is Man insatiable? What are human needs? How do we go about meeting them?

If the teacher is familiar with Maslow's Hierarchy of Needs, he can put them on the blackboard and introduce the students to these concepts. A modified diagram for this is included at the end of this unit.

Ultimately, we get to the question of whether greed (desire) is polluting our air. Whose greed? The manufacturer who wants profits, even if they poison the air? The consumer who wants goodies even if the manufacture of them poisons the air? The boy who dreams of the day he'll have "four on the floor: even if a stream of particles from his exhaust will poison his neighbor's air -- and his own.

B. Activities
1. If Man is greedy, and we still wish to have air for our grandchildren to breath, can we find a way to keep Man's greed from killing us? In other words, how can anti-pollution

measures be made profitable? Get an economics teacher to visit your class to discuss some of these items. For example, there is a large increase in the number of stocks on the market for companies who have as their business improving the environment. Environment I of Schenectady is one such Company.

2. If money permits, use a film such as "Take One Deep Breath" to illustrate what can result from unthinking pursuit of our own material desires.

3. At this point I could spend a day asking students what individual items they would like to pursue. I would leave it wide open, letting some students go to other myths and legends to see what insights they might yield about human behavior.

   Hopefully, two other ideas would emerge: one scientific, one political.

   a. Scientific
      1. Laboratory. Compare foils (HYE) left in different strategic places. The students will probably do very well thinking up their own, but one should be in the faculty smoking room, one or more should be in the student parking lot, and one should be in some area that we would hope was relatively free from auto or tobacco particulates at least.

      2. Historic or research. This could be a written report on some of the great air "episodes" like London, 1952, etc.

   b. Political
      1. Simple social action of the "write-your-Congressman" variety.

      2. More complex. Search for a local air-polluter. (In our town this turned out to be the incinerator at a near-by hospital). Many activities can be generated from this, depending on the nature of the class, transportation, etc. One could write to your local polluter asking what he intends to do. One could establish contact with city officials. In our community, such people have been willing to come in to speak to classes.

IV. Summary

What are some of the human assumptions which ultimatley relate to the way we treat our environment? Certainly Man's difficulty in doing any long term thinking when he perceives an immediate good is reflected in both Prometheus and "The Sorcerer's Apprentice." Man's urge to satisfy felt needs no matter what the cost -- his greed, if you will, -- is reflected in "The Fisherman and His Wife." As long as Man is unconscious that he acts this way, he can do little to improve his condition. When we examine these attitudes and assumptions, however, we begin to be able to think of ways of doing something about them.

D-3 Societal Problems for Class Discussion

a. Social Implications of Transportation Problems

It is important - vital - that the students realize that most of the questions raised by transportation problems are questions they will have to help find the answers to.

1. How important is a car to you?
2. Why don't more people use public transportation?
3. Make a list of changes that you feel would have to be made if people were to be won over to public transportation. (This should be a full period activity).
4. The electric car has been suggested as an alternative solution to urban transportation. Spend a period exploring the possibilities of the electric car. Would this start a chain of "Rent a lightning bug" stations around the periphery of central cities? Would you own your own and plug it in every night? What supplies electric power to electric cars? Would this merely transfer the problem from city streets to the areas around power plants? Etc.
5. Do other "developed" countries have this problem? How do they cope with the problems they do have?
6. Would there be any benefit to setting limits to allowable horse power for private transportation?
7. Think up seven (or forty) more questions of your own.

Activity:
Have one student assigned to keeping track of legislation in this area. When a public hearing is held in your area arrange a field trip to the hearing. If a student has done extensive research in this area he could ask to testify. He should have multiple copies of this testimony in this case.

b. Model for a Unit on Individualism

If The Environmental Handbook is available in class sets, the class could read "The Tragedy of the Commons" by Garret Hardin, p. 31.

1. Can the air be considered a "commons"?
2. Why can't we rely on individuals to be responsible in their use of the air?
3. What do we need to know economically if we are going to have fair rules about the use of the air?
4. What do we need to know politically?
5. What do we need to know scientifically?

Once the decision or realization has been reached that air is no longer a free good, several problems come to the fore: the difficulty of assigning a price to clear air, the choice that must be made between various means to force air to be considered a cost of production; a determination of who shall pay the price (and how): and the question of the level at which controls should be administered.

c. Model for a Unit on the Industrial Revolution

Usually students in a history course will study a sequence of events which constitutes an "industrial revolution." These processes are occurring today in emerging nations and the following questions might aid a class discussion in this area of investigation.

1. List some problems you envision if all the underdeveloped countries realize their dream of industrialization?
2. What economic stresses might occur?
3. How would we arrive at social, economic and political solutions to these problems?
4. What are "trade-offs"? Make a list of the "trade-offs" we make personally in everyday life.
5. What "trade-offs" do countries make? How are these "trade-offs" affecting society within the country?

d. Model for a Unit on Legislation

At the heart of our democracy has been the individual in the society and established legislative patterns. The questions which follow may aid your students in realizing that they may influence the passage of laws at various governmental levels.

1. What is your state doing about air pollution? Is there a problem in your state?
2. Do you have a local air pollution problem? If so what seems to be the cause?
3. What action does your city council (county board) take to alleviate local air pollution?
4. Could the problem be helped if there were greater cooperation between city and county?
5. How might air pollution ultimately affect local governmental structure?

Activity:
Arrange for a field trip to a meeting of one of your local governmental bodies. What goes on? How do they go about establishing rules for the betterment of community life?

e. Model for a Unit on Societal Ecology

The word "ecology" is no longer restricted to the scientific domain. Since ecology refers to the balances in nature that exist between living and non-living material, it is possible to establish the concept in relation to societal problems. The sequence of questions below is suggested as a model which will aid students in realizing that man takes an active part in an ecological pattern.

1. List the inconveniences caused by the "brown-out" in New York State during the temperature inversion of the last week in July, 1970.

2. What caused the "brown-out"?

3. How successful were voluntary controls, appeals to conscience, in limiting use of electric power?

4. How do we arrive at priorities when we consider:
   a. The polluting proclivities of fossil fuel power plants.

   b. The vital electric needs:
      1. elevators in tall buildings
      2. lighting for indoor residence, business, industry.
      3. name others.

   c. The luxury electric requirements:
      1. electric "gadgets".
      2. wasteful use of lighting.
      3. name others.

   d. Acquired "needs" such as air-conditioning.

5. If we move to the non-polluting electric car for urban transportation, what power problems may we anticipate?

E. Other Activities to Try

1. Disposal of Vinyl Chloride
2. Temperature Inversion
3. Effects of Two Different Pollutants on Plant Life
4. Distribution of Continental and Maritime Aerosols
5. Intensive Study of a Local Environment
6. Sedimentation Foil Experiments for Air Pollution Measurements
7. Social Science Questions
   ---Process Industries
   ---Waste Disposal
   ---Agricultural Control of Insects
   ---Systems Analysis
8. Role Playing
9. Auto Exhaust Activity
10. Noise Pollution

E-1 Disposal of Vinyl Chloride*

I. Introduction:

Societal use of increasingly new and varied products can lead to disposal problems. A number of plastics contain vinyl chloride ($CH_2 = CH\ Cl$). A prevalent method of disposing of plastics is to incinerate them despite restrictions.

II. Objectives:

1. To illustrate potential harmful products of vinyl chloride incineration.

2. To observe comparative biodegradation of plastics.

III. Materials:

wide mouth bottle, deflagrating spoon, distilled water, pH paper, silver nitrate solution (0.1N) and assortment of plastics which contain and do not contain vinyl chloride.

IV. Procedure:

1. Place a small amount of water in the bottle.

2. Ignite the plastic material and quickly lower the spoon and contents into the space above the water in the bottle.

3. When the bottle becomes full of smoke, remove the spoon and contents, cap the bottle and shake the bottle to dissolve the smoke in the water.

4. Test the pH of the solution and add a couple of drops of silver nitrate to a 5cc. sample of the solution to confirm the presence of the chloride.

5. Prepare 4 : 1 x 3 inch strips of the various plastics and measure the average thickness of each strip.

6. Bury the samples in the ground or in compost so that only about one inch remains above the soil level. Keep the soil moist.

7. Remove one of the samples each week for a month. Observe the appearance of each sample.

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*Source: 1970 General Chemistry Syllabus, State of New York and A.D. Muehlick

E-2 Temperature Inversion*

I. Introduction:

A temperature inversion may be formed by frontal activity, radiation losses from the earth's surface and high pressure systems. A temperature inversion reduces vertical turbulence since the lower layers of air cannot penetrate the inversion layer.

II. Objectives:

1. To study the factors that contribute to an inversion.

2. To determine the effect a temperature inversion has on turbulence.

III. Materials:

ice, hot water, shallow pan, 2 thermometers, glass column, ring stand, clamps, glass tube, cigarette(see following diagram).

IV. Procedure:

1. Set up the apparatus as diagrammed.

2. Place hot water in the pan and record the temperature on each thermometer after each period of one minute until there is a difference.

3. Blow smoke very gently into the bottom of the cylinder until there is a layer of smoke. Then observe.

4. Replace the hot water with ice water and repeat the previous procedures.

V. Questions:

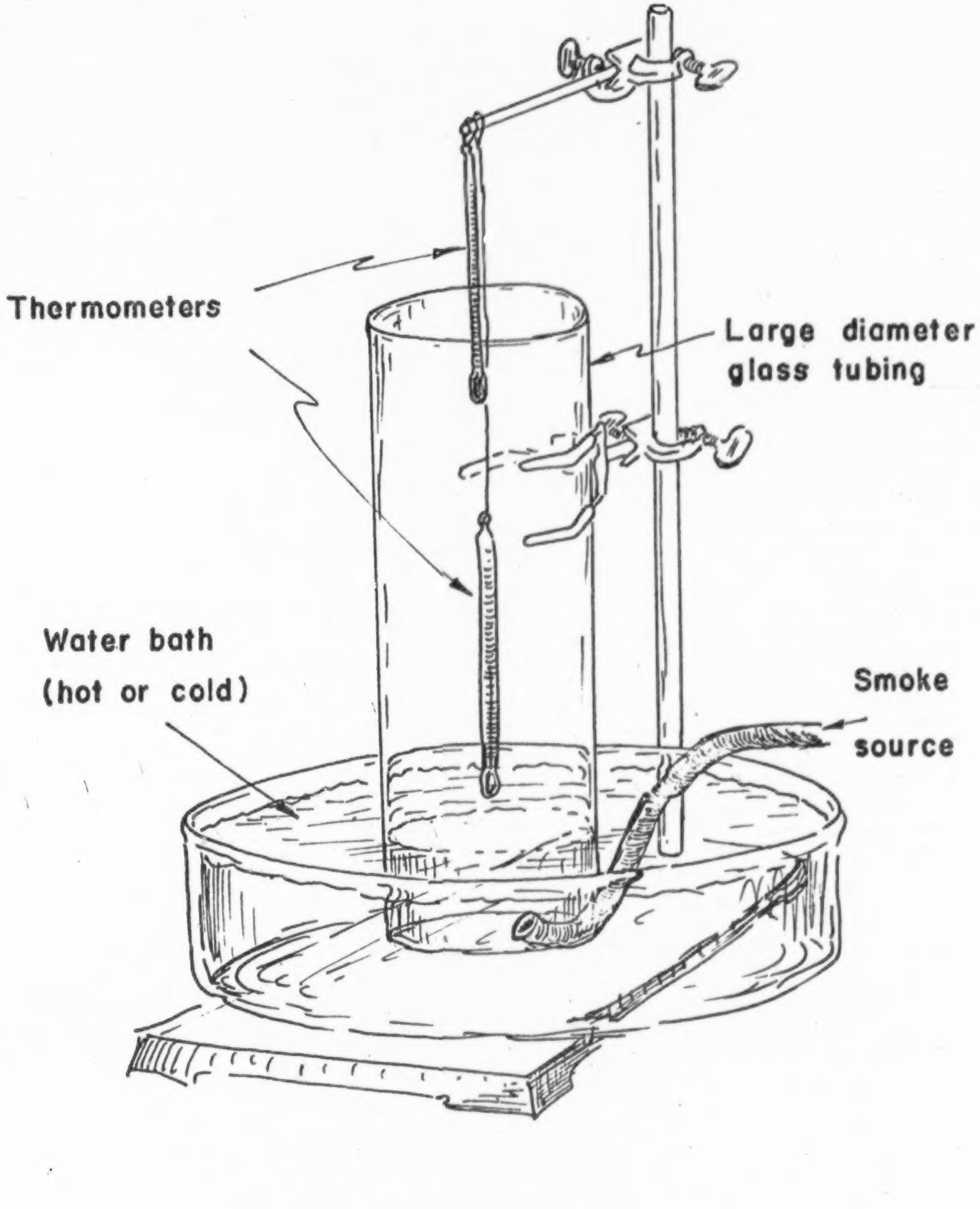
1. What is a temperature inversion?

2. Why is there little turbulence during a temperature inversion?

3. Why does an inversion usually produce smog in industrial areas?

*Source: Audrey Benson

INVERSION MODEL


Thermometers
Large diameter glass tubing
Water bath (hot or cold)
Smoke source

E-3 Effects of Two Different Pollutants on Plant Life*

I. Introduction:

Certain pollutants produce noticeable morphological changes that are easily recognizable by students. For the junior high school student a subjective experiment is all that is necessary to demonstrate the adverse effects of air pollutants.

II. Objective:

To show the effects of pollutants on plant life.

III. Materials:

6 petunia plants, matches, mason jars, cigarette

IV. Procedure:

1. Start your own seedlings and when one to two inches high begin the experiment.

2. Strike 2 or 3 matches in an ashtray and immediately invert the jar over the ashtray to catch the fumes.

3. Clamp the cover over the jar and place the smoke filled jar over one of the seedlings. Keep in place for 15 minutes.

4. Repeat the procedure with another seedling and cigarette smoke.

5. Carry on the activity for several weeks and pollute each seedling at least once a week. Use the remaining seedlings as controls.

6. Make daily notes of height, color, and general conditions of plants.

*Source: R. Stern

E-4 Distribution of Continental and Maritime Aerosols

I. Introduction:

Very small particulates less than 10μ may float for months in the atmosphere. Taking an ocean trip may not even decrease the high concentration of aerosols. Usually condensation nuclei (CN) counts are broken down into the following categories:

1.	100-1000 particles/cm^3	Oceanic or Polar Air
2.	1000-5000 particles/cm^3	country air
3.	5000-50,000 particles/cm^3	urban or city air
4.	greater than 50,000 particles/cm^3	large cities or highly industrialized area

II. Objectives:

1. To compare condensation nuclei concentrations over various continental features and to contrast these with levels over the Atlantic Ocean.

III. Materials:

Data charts (Source - Hogan, Bishop, Aymer, Harlow, Klepper & Lupo, 1967: Aitken Nuclei Observations over North Atlantic Ocean, Journal of Applied Meterorology, 6, No. 4, 726-727.)

IV. Procedure:

1. Plot CN concentrations vs. horizontal distance across the country. Use the peak readings found on the accompanying graph; let the students correctly locate the distances from a map or atlas.

2. Plot CN concentrations vs. distance from the continent obtaining data from the accompanying graph. Include a plot showing greater detail for the first 70 miles East of the U.S.

V. Questions:

1. In general, where do the greatest concentrations of CN occur? Why?

2. What influence does the continental aerosol have on the pollution concentration over the ocean? Compare continental aerosol influence on each side of the Atlantic Ocean.

3. What results would you expect if data were collected from a ship going from Greenland to South America?

Table I: East - West Cross Country Flight May 6-7, 1968

Location	Nuclei/cm
Seattle	40,000
Spokane	15,000
Great Falls	5,000
Grand Rapids	45,000
Duluth	80,000
Lake Superior	5,000
Lake Michigan	3,000
Traverse City	10,000
Lake Huron	2,000
Flint	35,000
Lake Erie	32,000
Akron	92,000
Williamsport	5,000
Schenectady	35,000

Table II: Coastal U.S. and Atlantic Ocean

Location		Nuclei/cm^3 x 10^{-3}
Lat - N	Long - W	
39°30'	65°	6
39°30'	66°	9
40°00'	67°	23
40°00'	68°30'	24
40°30'	69°30'	16
41°00'	70°30'	24
41°00'	72°00'	25
41°00'	72°30'	41
41°00'	73°00'	83

E-5 Intensive Study of a Local Environment

I. Objectives:

1. To find "normal" conditions and determine pollution conditions.

2. To look for changes over time; determine rates of change; make projections into future.

3. To compare with other local environments.

4. To look for cycles, systems, processes, various types of pollution suitable for division of student labor or long term single student investigations.

5. To emphasize basic environmental concepts such as interrelationships, interdependence, complexity, change.

6. To collect similar data each year and compare to determine long term trends.

II. Procedure:

1. Measure Meteorological Parameters - temperature variations, vertical and horizontal profiles, humidity, visibility, wind direction and velocity, pressure, sky conditions, precipitation, radiation-incoming and outgoing.
   a. compare data for areas of local influence - black top, grass, bare soil, trees, tall grass, etc.
   b. relate data to longer external influence - topography, weather patterns, buildings, etc.

2. Collect airborne particulates - aluminum sedimentation foils, cellophane tape collector, high volume air sampler, dust collector jars, rain water collection for solid content, condensation nucleus counter measurements, rain drop size spectrum measurements (relate to cleansing characteristics).
   a. Determine average mass of material collected; variations in average mass collected at same locations at the same time, at different times and at different locations.
   b. Measure sizes (radius, diameter or volume) and size distributions.
   c. Determine qualitative characteristics of collected materials-shapes, structure and other properties perhaps leading to identification.
   d. Measure the number of particles - total number, number per unit volume, number per unit area.

3. Measure gaseous components of atmosphere.

E-6 Sedimentation Foil Experiments for Air Pollution Measurements

I. Introduction:

A network of sedimentation foils placed over a fairly large geographic area can give an indication of local air pollution and its sources. The foils will collect particles that settle out of the air and are larger than the 10-50μ range.

II. Objectives:

To determine some characteristics of local pollution by measuring the amount of the larger size non-soluble particulates collected on sedimentation foils.

III. Materials:

Heavy-duty aluminum foil, GE silicone adhesive resin SR-516, support stands, toluene solvent, analytical balance, drying oven.

IV. Procedure:

1. Determine specific experiment(s); select appropriate site(s)(Keep experiment simple at first); determine additional information desired - such as distance from highway, smokestack, or other specific source, height above ground, etc. (See Appendix F-4).

2. Prepare appropriate number of foils:
   a. Cut aluminum to 4.0 cm x 7.4 cm foils(standard size for direct comparisons with Project HYE and other published data; Number the foils using ball point pen impression(see diagram 1a).
   b. Dilute coating material 2 parts toluene, one part Sr-516. Coat foil liberally using a small brush or drip on and spread with stick. Leave about 1 cm of one end uncoated for easier handling.
   c. Bake coated foils 1-2 hours @ 70°C in drying oven (or box with light bulb), or dry at room temperature for about 48 hours until weight stability is achieved (test by weighing). Keep prepared foils in a dust-free area.

3. Construct suitable stands sufficiently sturdy to withstand local winds and weather(see diagrams 1b, 1c).

4. Weigh foils to nearest 0.1 milligram if possible just before mounting and exposing.

5. Mount and distribute foils. Expose foils for 30 days. (If exposed for shorter time, extrapolate to 30 days for direct comparison with published data).

6. Record dates, locations, special conditions, initial weights. Inspect samples periodically during exposure.

7. Collect samples, and oven dry unless no rain has occurred in 48 hours. Reweigh foils. Note special conditions or discrepancies which would invalidate results.

8. Relate to meteorological, topographical and other pollution data available for the same period. (Contact local and state health departments and atmospheric, meteorological agencies).

9. Make optical observations of particles collected on foil using microscope or binocular microscope. Coat glass slides with Sr-516 to facilitate this part of work. Make size distribution measurements.(See Experiment B-15).

CAUTION:

1. Keep wind from bending foil samples.
2. Keep coating away from moisture until dried.
3. Choose locations not accessible, or at least inconvenient to, the idle and the curious.
4. Don't make the coating on the foil too thin.

V. Questions:

1. What are the weight increases, average weight increases, and frequency distributions?

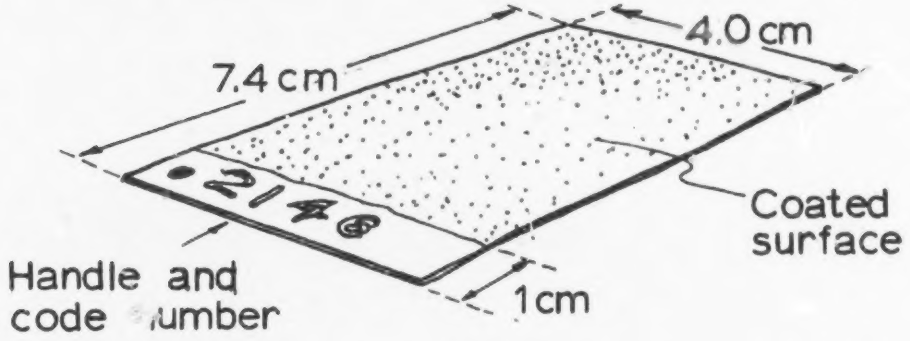
2. What is the weight increase in tons per square mile per month?

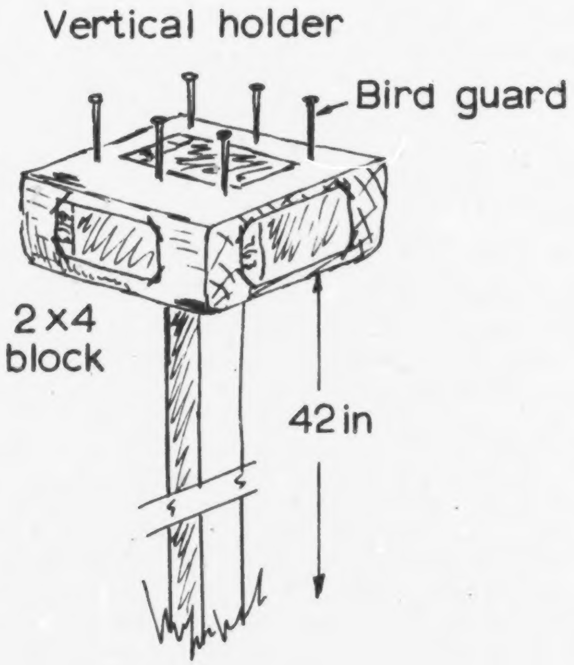
3. What is the relation of weight increases to locations (city, suburbs, country), pollution sources(beware of false conclusions here), prevailing winds?

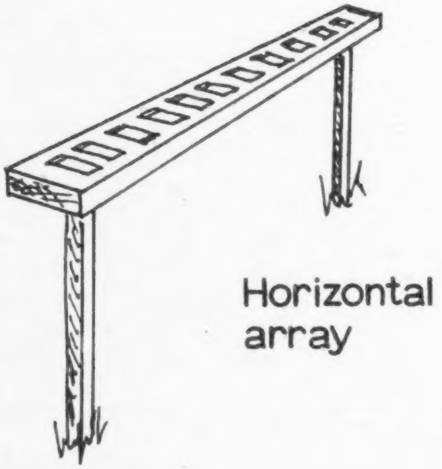
VI. Comment:

Measurements of this sort involve original research for individual localities. If the work is carefully done, the results would be of sufficient interest to others to warrant publication of the student's work in an appropriate science or teachers' journal or magazine. Foils have been placed at the Grand Canyon and Lake Powell, and plans exist to use this technique in a few other metropolitan areas throughout the country. Comparisons can then be made for different localities to permit larger scale trends to become apparent. The individual results serve as a bench mark against which future measurements can be compared. Thus long term changes in pollution levels may be detected.

FOIL SAMPLER AND HOLDERS


7.4 cm
4.0 cm
•2146
Coated surface
Handle and code number
1 cm


Vertical holder
Bird guard
2×4 block
42 in


Horizontal array

E-7 Social Science Questions

These questions are intended to aid the social studies teacher in stimulating class discussion or projects when certain broad areas of the social science discipline are presented in class. The questions are suggested ways to proceed and are not meant to be followed explicitly.

Process Industries

A. Activities:

1. Use the bibliography for sources of information relative to radioactive sources .

   (a) What radioactive isotopes are potentially present in uranium mining dusts?
   (b) What biological effects might these isotopes have?
   (c) What is a half-life? Contrast this term with biological half-life.
   (d) What is "normal background radiation?"

2. Obtain a geiger counter and see what background radiation is in your school. Where does it come from?

3. Questions to answer:

   (a) What is steel used for?

   (b) Can we find out what proportion of steel goes into?
      (1) car manufacture
      (2) structural steel for reinforced concrete
      (3) bridges
      (4) tin cans
      (5) appliances

   (c) What would be the effect on the steel industry if the population remained constant but cars were built to last for ten years?

   (d) What do we know about reprocessing of scrap steel?

Waste Disposal

A. Questions:

1. How many methods of solid waste disposal can you think of? What pollution risk does each incur?

2. How much waste is potentially recyclable - assuming that we could encourage people to recycle wastes?

3. What is the waste production per capita in your community? In the United States? How does this compare with the rest of the world?

4. What gaseous or particulate matter is put out by incinerating plastics?

Agricultural Control of Insects

A. Questions:

1. What are the purposes of insecticides?

2. How do they differ in chemical structure and mode of action?

3. Select a commonly used insecticide and examine the consequences of its elimination in terms of the total ecological picture.

4. What precautions should be exercised in the use of spray, aerosols, fumigants to minimize risks?

5. What attempts have been made to find alternative methods of insect control?

Systems Analysis

A. Questions:

1. What is the relationship between a forest and a water shed?

2. What can a private citizen do to work for sane silviculture practice?

3. Why would he want to? (What's in it for him?) List reasons. (This could take up quite a bit of time).

4. What is a "climax" forest?

5. How much importance should we attach to the economic value of a forest? Long term? Short term?

6. Can you "bring back" a forest destroyed by improper silviculture? With what kind of trees? Deciduous? Coniferous? Red wood?

7. List a number of enemies of the forest.

E-8 Role Playing

I. Introduction:

Many students in junior high school enjoy acting especially when they are able to take adult parts.

II. Objectives:

1. To introduce students to various types of media.

2. To have students write an "air pollution interview" script for some media form.

3. To involve students in a group activity.

III. Materials:

script, media apparatus

IV. Procedure:

There is no set pattern since the teacher is best able to judge about the necessary steps that should be followed. This type of activity is especially good for so called slow groups of students.

E-9 Auto Exhaust Activity

I. Introduction:

The major pollutants from automobile exhausts are carbon monoxide, sulfur oxides, hydrocarbons, nitrogen oxides and particles. The automobile accounts for 60% of the total source pollution emitted every year in the United States. The major pollutants in the automobile exhaust are carbon monoxide, hydrocarbons and nitrogen oxides.

II. Objectives:

1. To isolate the major pollutants found in automobile exhaust fumes.

2. To contrast the pollutant output from a new versus an old automobile engine.

3. To contrast pollution output from a small versus a big engine.

III. Materials:

gas detection tubes, plastic bag, various types of cars

IV. Procedure:

1. Collect exhaust gas in a plastic bag for a few seconds.

2. Using the gas detection tubes, test for each type of gas.

3. Repeat the same procedure for a new car, old car, small compact, both old and new.

4. Test during idling while engine is warm and cold.

5. Test after cars have been driven for the same amount of time at high speeds.

V. Results:

1. Prepare a summary table to indicate type and amount of pollutant for each vehicle under the various test conditions.

VI. Questions:

1. Which gas seems to be evident in the greatest concentration? Is it the same gas for all operating conditions tested?

2. What conclusions can be drawn for old versus new cars under the same conditions?

3. What conclusions can be drawn for large versus small cars under the same conditions?

E-10 Noise Pollution

I. Introduction:

The intensity of sound may give discomfort, pain and damage to the auditory system over an 8 hour day. Although the frequency of the noise is essential to the elimination of potentially hazardous noise problems it is easier to monitor sound intensity levels.

While evidence indicates that levels of noise below 75 db are not dangerous, progressive noise - induced deafness is known to occur through continuous 8 hour exposure in the 80 to 85 db range.

II. Objectives:

1. To determine local levels of intensity of sound and estimate their potential as a health hazard.

III. Materials:

audiometer (see A-11) Appendix F-8.

IV. Procedure:

1. Referring to Appendix F-8, use the db ratings to calibrate the instrument.

2. Measure the level of sound intensity at various areas(e.g. school, intersections, store, etc.)

3. Repeat your measurements at various times during the day and during the week.

V. Results:

1. Rank the sites monitored from the most dangerous to the least dangerous.

VI. Questions:

1. How does your ranking agree with Appendix F-8?

2. Can you suggest flow patterns or alternative measures for alleviating dangerous areas?

3. How would you go about detecting frequencies that might be dangerous to the auditory system?

F. Appendix--Collection of Tables, Graphs, Data, and Useful Facts

1. Beaufort Scale
2. Pollutants and Sensitive Vegetation
3. Conversion Factors
4. Sample Computation for Sedimentation Foil Experiments
5. Units for Reporting Air Pollution Measurements
6. Noise Levels from Various Activities and Thresholds of Hearing
7. Life Style Book List
8. Science Fiction for Scenarios
9. Historical Bibliography

F-1 Beaufort Scale

No.	Description of Wind Effect	Equivalent in Knots
0	Smoke rises vertically	less than 1
1	Wind direction shown by smoke drift but not by wind vane	1–3
2	Wind felt on face; leaves rustle; vane moved by wind	4–6
3	Leaves and small twigs in constant motion; wind extends light flag	7–10
4	Raises dust and loose paper; small branches are moved	11–16
5	Small trees in leaf begin to sway; crested wavelets form on inland water	17–21
6	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	22–27
7	Whole trees in motion; inconvenience felt in walking against wind	28–33
8	Breaks twigs off trees; generally impedes progress in walking against wind	34–40
9	Slight structural damage occurs; chimney pots and slate removed	41–47
10	Seldom experienced inland; trees uprooted; considerable damage occurs	48–55
11	Very rarely experienced; widespread damage	56–65
12	Hurricane force	above 65

F-2 Pollutant and Sensitive Vegetation

Pollutant	Sensitive Vegetation
Ozone	Spinach, tobacco, tomato, bean
PAN	Petunia, pinto bean
NO_2	Petunia, bean, tomato
SO_2	Potato, alfalfa, white pine
HF	Gladiolus, ponderosa pine
Cl_2	Cucumber, begonia
CH_2	Tomato, azalia

F-3 Conversion Factors

1. 2 knots = 1 meter/sec. = 2 naut. m.p.h. = 3.30 m.p.h.
2. 1 km. = 1000 m. = 0.621 stat. miles = 0.540 naut. miles
3. 2.54 cm. = 1 inch
4. 30.5 cm. = 1 foot
5. 1.0 m. = 3.28 feet
6. 1 cm. = 10 mm. = 0.394 inches
7. 1 micron (μ) = 10^{-4} cm.
8. 454 gm. = 1 pound

F-4 Sample Computations for Sedimentation Foil Experiments

1. Method for converting 30 day foil weight increases in milligrams to tons per square mile per month;

   a) Convert foil weight increases in milligrams to tons. For example average weight- 9.3mg.

   $$9.3\text{mg} \times \frac{1\text{g}}{10^3\text{mg}} \times \frac{1\text{kg}}{10^3\text{g}} \times \frac{2.2\text{lbs}}{1\text{kg}} \times \frac{1\text{ton}}{2\times10^3\text{lbs}} = \frac{20.46\text{tons}}{2\times10^9} = 10.23\times10^{-9}\text{tons}$$

   Note: Each fraction used to multiply 9.3mg has a value of 1. Therefore the value of the weight 9.3mg remains unchanged, only the unit of weight is changed.

   $$\frac{10.23\times10^{-9}\text{tons}}{9.3\text{mg}} = 1.1\times10^{-9}\frac{\text{tons}}{\text{mg}}$$

   $$1.0\text{mg} = 1.1\times10^{-9}\text{tons}$$

   b) Similarly, convert foil sample area to square miles
   Area of foil = 4.0cm x 6.4cm = 25.6cm^2

   $$25.6\text{cm}^2 \times \frac{1\text{in}}{2.54\text{cm}} \times \frac{1\text{in}}{2.54\text{cm}} \times \frac{1\text{ft}^2}{144\text{in}^2} \times \frac{1\text{mi}}{5280\text{ft}} \times \frac{1\text{mi}}{5280\text{ft}} =$$

   $$25.6\text{cm}^2 \times \frac{1\text{in}^2}{6.45\text{cm}^2} \times \frac{1\text{ft}^2}{1.44\times10^2\text{in}^2} \times \frac{1\text{mi}^2}{27.9\times10^6\text{ft}^2} = \frac{25.6\text{mi}^2}{259.\times10^8} =$$

   $$\frac{25.6\text{mi}^2}{2.59\times10^{10}} = 9.88\times10^{-10}\text{mi}^2$$

   c) Therefore, for a sampling period of 30 days:

   $$\frac{10.23\times10^{-9}\text{tons}}{9.88\times10^{-10}\text{mi}^2} = 1.04\times10^1\text{tons/mi}^2\text{/month} = 10.4\text{tons/mi}^2\text{/month}$$

2. Alternative method using standard foil coating size (4.0cm x 6.4cm)

   $1.0\text{mg} \cong 1.13\text{tons/mi}^2$
   Thus, for average foil deposition of 9.3mg

   $$9.3\text{mg} \times \frac{1.13\text{tons/mi}^2}{1.0\text{mg}} = 10.5\text{tons/mi}^2$$

   Compare this with 10.4tons/mi^2 of previous computations.

3. For finding total sedimentation sampling area ie 15 mile radius of Albany Airport

   a) Area = $\pi r^2 = 3.14(15\text{mi}^2) = 706.5\text{mi}^2$

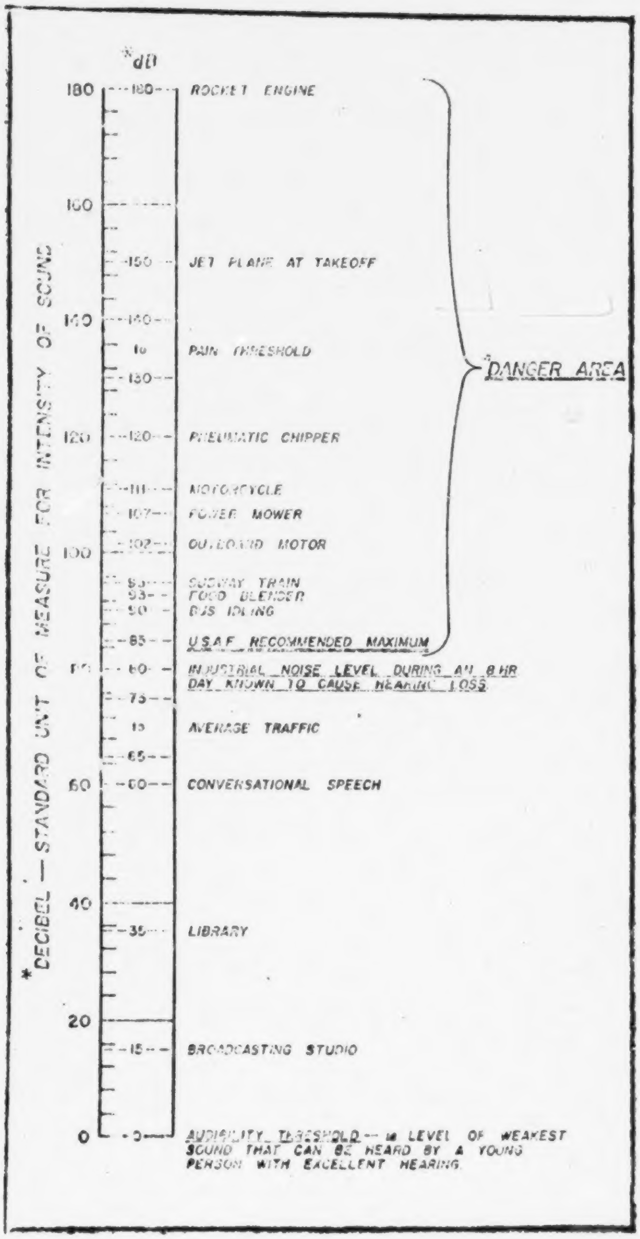
   b) $10.4\text{tons/mi}^2 \times 706.5\text{mi}^2 = 7348\text{tons}$

F-5 Recommended Units for Reporting Air Pollution Measurements

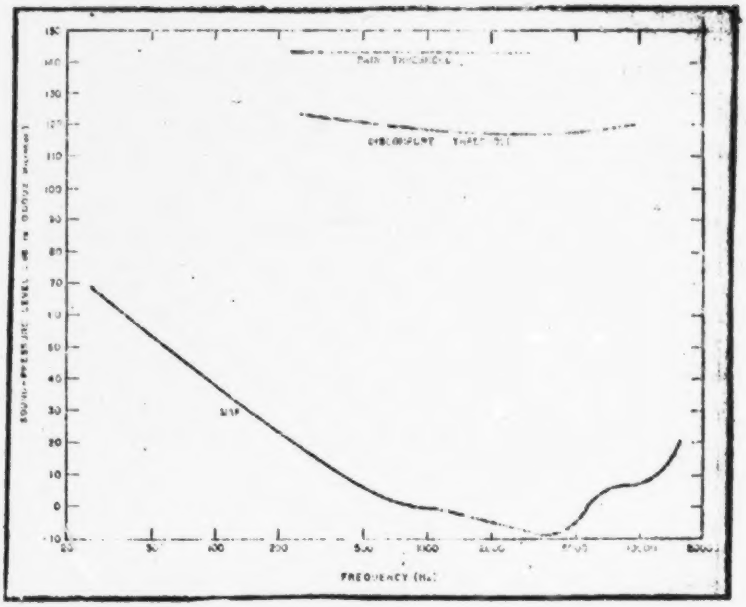
Item measured	Recommended units	Observed ranges
Particle fallout		
Count	Number per square centimeter per time interval	—
Weight	Milligrams per square centimeter per time interval	0.5 to 135 mg/cm^2 month
Airborne particulates		
Count	Number per cubic meter	10×10^6 and up particles/m^3
Weight	Micrograms per cubic meter	10–5000 μg/m^3
Gases and vapors	Micrograms per cubic meter	Varies greatly
Instantaneous light transmission	Percent transmitted	0–100%
Visibility	Kilometers	—
Volume emission rates	Cubic meters per minute	1.5–300 + m^3/min
Sampling rates	Cubic meters (decimeters or centimeters) per minute	10 cm^3/min to 3 m^3/min
Temperature	Celsius scale	--
Time	0000 to 2400 hours per day	—
Pressure	Millimeters of mercury	—
Velocity	Meters per second	0–100 m/sec
Gas volumes	Reported at 760 mm Hg and 10 °C	--

F-6 **Noise Levels and Threshold of Hearing**

Noise Levels from Various Activities in an Urban Community



Thresholds of Hearing vs. Frequency



F-7 Life Style Book List

Class Sets

De Bell, Garrett, The Environmental Handbook, Ballantine, 1970.

Good for reading in whole or in part. The following essays are particularly pertinent for this unit.

1. De Bell, Garrett, "Education and Ecology," p. 127

   ". . . we are not providing the kind of education that will allow the electorate to evaluate the choices that are, or will be, available to them."

2. Fischer, John, "Survival U.: Prospectus for a Really Relevant University," p. 134.

   "All these courses (and everything else taught at Survival U) are really branches of a single science. Human ecology is one of the youngest disciplines, and probably the most important. It is the study of the relationship between man and his environment, both natural and technological. It teaches us to understand the consequences of our actions--. . ."
   (italics by svs)

3. De Bell, Garrett, "Recycling," p. 214.

   A practical guide to the optimum use of material and the avoidance of waste.

4. Hardin, Garrett, "The Tragedy of the Commons," p. 31.

   Using the analogy of the pasture held in common by a whole community, Hardin says:

   > Each man is locked into a system that compels him to increase his herd without limit--in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

   He quotes Charles Frankel:

   > Responsibility is the product of definite social arrangements.

5. Snyder, Gary, "Four Changes," p. 323 (In The Environmental Handbook this is attributed to the Berkeley Ecological Centre)

   The four areas in which imaginative proposals are made are:

   a. Population
   b. Pollution
   c. Consumption
   d. Transformation

6. White, Lynn, Jr., "The Historical Roots of our Ecological Crisis," p. 12.

   White says:

   > Christianity, in absolute contrast to ancient paganism and Asia's religions (except perhaps Zoroastrianism), not only established a dualism of man and nature but also insisted that it is God's will that man exploit nature for his proper ends. . . . . By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects.
   >
   > The greatest spiritual revolutionary in Western history, Saint Francis, proposed what he thought was an alternative Christian view of nature and man's relation to it: he tried to substitute the idea of the equality of all creatures, including man, for the idea of man's limitless rule of creation. He failed. Both our present science and our present technology are so tinctured with orthodox Christian arrogance toward nature that no solution for our ecological crisis can be expected from them alone.

Krutch, J. W., Thoreau: Walden and other Writings, Bantam

There is no particular reason why the teacher should not purchase his own favorite edition of Thoreau's Walden. This edition is cheap, contains other pertinent essays, and an introduction by Joseph Wood Krutch.

Skinner, B. F., Walden Two, Macmillan, 1948 (paper)

This and Walden are both synopsized in the study guide.

Pamphlet

Berube, Allan, "Ecology: Making Peace with Nature and With Each Other: A Green Paper," Boston Area Ecology Action, 925 Massachusetts Avenue, Cambridge, Massachusetts 02139.

Since this item is free, in the interests of ecological consistency it might be well to order a few copies and then reproduce what you need through your school facilities.

Berube Says:

> "The purpose . . . is to examine the traditional conservationist and anti-pollutionist approach to environmental problems, to explain and illustrate the new ecology action approach, and to explore the implications of seeing 'non-environmental' problems from an ecological perspective."

Literature to have available in your library

The Bhagavadgita

The edition we have, complete with Sanskrit text, is hardcover, published by Harper and Brothers. Abbreviated editions are available in paperback (Signet).

We found it useful to abstract lists of epigrammatic statements, ditto them, and pass them to the students. Thoreau was well-read in Hindu philosophy, and admitted to read widely and frequently in The Bhagavadgita. Occasionally one has students who are interested in Eastern Religion. This book is a good starting point for such a student. He could compare it with Herman Hesse's Siddhartha.

A good way of exploring alternative life styles.

Chase, Stuart, Guides to Straight Thinking, New York; Harper and Row, 1956

Since the whole area of environmental studies and life styles can lend itself to a great deal of sentimentalism and emotionalism, a book like this can be a useful antidote. Use in conjunction with Hayakawa's Language in Thought and Action. Particularly useful are his chapters exposing common fallacies: over-generalizing, false analogy, arguing in circles, etc.

Faulkner, William, The Bear.

This is available in most school libraries, either in anthology or in Go Down Moses. For our purposes we would recommend the full version of The Bear which can certainly be read by competent junior and seniors, although it poses difficulties.

It provides a good opportunity to explore, in literature, the highly individualistic life-style which is part of the romance of America.

Hardin, Garrett, ed., Population, Evolution, and Birth Control, San Francisco, Freeman, 1969.

One of the several good anthologies which are beginning to appear.

Sample items:

Thomas Malthus, "An Essay on the Principle of Population"
Harrison Brown, "The Challenge of Man's Future"
J. H. Fremlin, "How Many People Can the World Support?"
William Petersen, "Marx versus Malthus"
Garrett Hardin, "Interstellar Migration and the Population Problem"
Robert Frost, "The Road Not Taken"

Hayakawa, S. I., Language in Thought and Action, Harcourt Brace and World, 1964.

A semantic approach to the whole problem. One could, of course, start with a course in semantics, and then move to environmental aspects. Especially useful are chapter 2, Symbols, and chapter 3, Reports, Inferences, Judgments.

Hermann Hesse, Siddhartha, New York: New Directions, 1964.

This short novel is a good introduction to Eastern concepts of the Universe. It provides a useful contrast to many Western assumptions. Emphasis is on the unity of the universe, and on the cyclical nature of experience. Compare with Lynn White, Jr.'s essay in The Environmental Handbook. Compare White's exposition of the Western world view with Hesse's examination of the Eastern world view. What implications have each for choosing an ecologically valid life style?

Huxley, Aldous, Brave New World and Brave New World Revisited, New York: Harper, 1960.

If you prefer you could use this instead of Walden Two. Many of the concepts of social control are the same. The difference lies in tone, emphasis, and style (Skinner is no stylist!) This would be included in the list of Utopian societies that some student may want to compile. A compare and contrast paper using this and Walden Two might be fun for somebody.

Huxley, Aldous, Island, New York: Harper and Row, 1962.

This is worth teaching by itself, if you have a class of students who really want to explore The Good Society. The people on the Island of Pala are eminently reasonable. Huxley predicts that the rest of the world will not allow them to continue to be reasonable.

Krutch, Joseph Wood, The Measure of Man, Charter Books, 1962.

Krutch is also the editor of the edition of Walden which we recommend. He is violently opposed to B.F. Skinner's ideas, and raises some excellent objections to Skinner's "human engineering" which some students may want to explore.

Miller, Perry, The American Puritans, Doubleday, 1956.

In a very readable anthology of selections from the writings of the Puritans, Perry Miller provides us with a sampling of items which demonstrate some early views of The Good Society on which our country was founded. Read the selections with an eye to identifying assumptions about the good life and the relationship between man and his world.

Shepard, Paul, and Daniel McKinley, The Subversive Science: Essays Toward an Ecology of Man, Boston, Houghton Mifflin, 1959.

> My choice of title is not facetious. I wish to explore a question of growing concern. Is ecology a phase of science of limited interest and utility? Or, if taken seriously as an instrument for the long-run welfare of mankind, would it endanger the assumptions and practices accepted by modern societies, whatever their doctrinal commitments?
>
> --Paul B. Sears, "Ecology--A Subversive Subject," Bio-Science 14(7): 11, 1964.

This book is comprehensive enough that it could be used as one of the texts for a full-fledged course. It is however geared for the mature and well-informed, and probably would not be appropriate for most high school groups. Sample titles include:

1. Samuel Brody, "Facts, Fables, and Fallacies on Feeding the World Population"
2. Alan Watts, "The Individual as Man/World"
3. Colin Bertram, "Man Pressure"
4. G. Evelyn Hutchinson, "Fifty Years of Man in the Zoo"
5. Rene J. Dubos, "Second Thoughts on the Germ Theory"
6. G. M. Woodwell, et. al., "A-Bombs, Bugbombs, and Us"
7. Frank E. Egler, "Pesticides---In Our Ecosystem"

Watts, Alan, *The Book*, Pantheon, 1966.

This is for the student who enjoys *Siddhartha* and *Island.* There are probably many books which help us look at ourselves in new ways. However Watts is a useful choice since he throws light on Eastern ways of looking at self in relationship to the universe. Currently this way appeals to many young people.

Watts, Alan, *Psychotherapy East and West*, Pantheon, 1961.

The important thing about Alan Watts is that he puts concepts in ways that are unusual for most of us. In Chapter 2, "Society and Sanity," he says:

> An enduring organism is simply one that is consistent with its environment. Its climate and its food agree with it; its pattern assimilates them, eliminating what does not agree, and this consistent motion, this transformation of food and air into the pattern of the organism, is what we call its existence. There is no mysterious necessity for this to continue or discontinue. To say that the organism *needs* food is only to say that it *is* food. To say that it eats *because* it is hungry is only to say that it eats when it is ready to eat. To say that it dies because it cannot find food is only another way of saying that its death is the same thing as its ceasing to be consistent with the environment.

He suggests that each society sets up its own set of rules for playing a game of living in that society. The first rule of the game for each society is, "This game is *serious*, i.e., is not a game." He goes on to point out ways in which our game frustrates us:

> For example, one of our greatest assets for survival is our sense of time, our marvelously sensitive memory, which enables us to predict the future from the pattern of the past. Yet awareness of time ceases to be an asset when concern for the future makes it increasingly certain that beyond a brief span we have no future. If, too, man's growing sensitivity requires that be become more and more aware of himself as an individual, if social institutions are designed more and more to foster the unique person, not only are we in great danger of overpopulating but also we are betting and concentrating upon man in his most vulnerable and impermanent form.

White, E. B., *The Second Tree From the Corner*, New York: Harper, 1954.

E. B. White has been concerned about the environment for several decades and has recorded his concern in the pages of *The New Yorker*. One particularly good story expressing this concern is "The Morning of the Day They Did It." In "About Myself" White describes himself in a way which reveals the dehumanizing effects of some aspects of our society. "The Door" again touches on dehumanization, comparing a man in the pressures of society with an experimental rat.

White is a long time disciple of Henry David Thoreau. Several of the pieces in this volume are worth reading as one reads Walden. Try "The Retort Transcendental." Or get a copy of White's One Man's Meat and read his imaginary letter to Thoreau.

Magazines

Earth Day produced a spate of environmental articles. The environmental movement has also caused certain magazines to set up departments on the environment. Saturday Review has a monthly "Earth Watch." Time has an environmental section. Furthermore, a number of magazines devoted whole issues to the subject of the environment during the spring of 1970; magazines so varied in their normal pursuits as Fortune (February, 1970) and Ramparts (May, 1970). Many of these turn their attention to the relationship of life-style to problems of the environment.

In addition to the above, we list here a sampling of periodical literature which appeared in general magazines during the spring of 1970. Our purpose is to show the range, not to provide an exhaustive bibliography.

Barthlemes, W., "Pollution and the Poor," Commonweal, 91:549-5 F 20 '70

Bernstein, V., "Earth, Love it or Leave it," Redbook, 135:97 May, 1970.

Collier, P., "Ecological Destruction is a condition of American Life," interview with Paul Ehrlich, Mademoiselle, 70:188-9, April, 1970

Dale, Edwin L., Jr., "Economics of Pollution," New York Times Magazine, pp. 27-29, April, 19, 1970.

"Earth Watch," Saturday Review, 53:60, March 7; p. 58, April 4; pp. 60-1, May 2, 1970.

"Forty ways you can Depollute the Earth," Mademoiselle, 70:112, April, 1970.

Frome, M., "Cross-purposes in the Environmental Crusade," Field and Stream, 75:42, May, 1970.

Harrington, Michael, "Politics of Pollution: Why are the Corporations Cooperating?" Commonweal, 92:111-14, April 17, 1970.

Keller, G., "New Courses on the Environment," Seventeen, 29:36, May, 1970.

Nixon, Richard, and Edmund Muskie, "Environment: A National Mission for the Seventies," Fortune 81:98-148, February, 1970.

Rodgers, W. H., Jr., "Tacoma's Tall Stack," Nation, 210:553-7, May 11, 1970.

"Trade-offs for a Better Environment," Business Week, pp. 62-3, April 11, 1970.

Film Strips

"Crisis of the Environment" The New York Times, 1970

This consists of five film strips, five accompanying records, five booklets, and a class supply of Ringleman charts. The titles include:

1. "Man: An Endangered Species?"
2. "Breaking the Biological Strand"
3. "Vanishing Species"
4. "Preserve and Protect"
5. "Population Explosion"

The series is beautifully photographed, and seems to be responsibly written. In addition to a thorough exposition of the various problems, it quotes widely from scientists and from other people who are intimately concerned with environmental problems: Dr. Paul Ehrlich, Dr. Barry Commoner, Dr. Robert White-Stevens, Henry David Thoreau, Harry Caudill, and others.

The text is adult. This may pose problems for use of the film strip with younger or slower groups. Suggestion: let an interested student have as a project the writing of a new continuity in simpler terms so that the film strips may be used with a wider range of classes.

The booklets or teachers' guides contain study outlines which could be used if one wanted to expand this unit into a full-fledged, one semester course. They also contain questions for discussion, suggested activities, and bibliographies.

In addition to using the film strips as an adjunct to the course, one could use them in several other ways:

1. As student projects. Students could familiarize themselves with the strips, and offer their services to other teachers. If other teachers were aware that your class was running a speakers' bureau, they could invite your students over to give an illustrated talk on some environmental problem.

2. Environmental Ambassadors. This is a project of the SURVIVAL club in Linton High School. Environmental ambassadors have prepared themselves to give talks to elementary school children. They travel in pairs, going either to a single elementary class (4-6) or perhaps to an assembly of several classes. This works in several ways. First, many elementary children are aware of "pollution" and welcome the opportunity to talk to someone about it. The film strip helps focus their questions. The novelty for the child in having "one of the big kids" come in and give a talk enhances the whole situation. The harassed elementary teacher is relieved of the need to rush out and bone up on still another topic.

   And the ambassadors, themselves, learn more than anyone else by having to teach.

F-8 Science Fiction for Scenarios

Asimov, Isaac, The Caves of Steel, New York, Doubleday, 1954.

Interesting projection of a highly urbanized world of the future.

Barthelme, Donald, "Game," from Unspeakable Practices, Unnatural Acts, New York, Farrar, etc., (also Bantam (n4411)

Chilling short story of the "what if the guy who is in a position to push the button is crazy" variety.

Bradbury, Ray, "There Will Come Soft Rains," The Martian Chronicles, Bantam (S4843)

From the English teacher's point of view this is fun to teach, as there is no human character, and the whole effect is achieved through personification. Generally this is another good "what if" story, of the last house left standing in California.

Camus, Albert, The Plague, Modern Library (t69)

This is not strictly science fiction, although it is speculative. However, in this novel of several good men and their ways of facing disaster, many of the problems of human responsibility and of heroism in the face of despair are raised. For the philosophically oriented class, it raises the question: what does the good man do in times of cataclysm?

Capek, Karel, R. U. R., (46293) R. E. Washington Square Press.

This play, written in 1923, anticipates many of the questions that have arisen in recently years, especially about automation, the future of man in an increasingly mechanized society, and so on.

Miller, Walter, A Canticle for Leibowitz, (S2973) Bantam

This book is difficult, so save it for your best students. Stylistically alone, it is one of the ten best science fiction novels of all time. Its theme is the conflict between science and religion. Miller probably loads the deck slightly in favor of religion, but he really does

Miller, Walter, (continued)

play fair, and make a good case for the need of a synthesis of both. He takes mankind through three ages in the future, during which man recapitulates his whole experience since the fall of Rome. In addition to the seriousness of the theme, Miller is concerned with matching his prose style to his ideas; the result is a lightly ironic style which nudges at you throughout the book, making sure you understand.

Vonnegut, Kurt, Player Piano, UN23 Avon

A good satire on the effects of the automated society upon men. Men replaced by machines begin to build up a social resistance to managers of factories. Eventually there is an all out revolt, during which the machines are destroyed. However, before the book is over, someone is already inventing a new labor-saving device, and we realize we're back on the merry-go-round.

Wyndham, John, Rebirth, (01638) Ballantine

This book deals with a post-holocaust society in which a great deal of mutation has taken place. Usages and customs have built up as a result of the society's attempt to account for the biological disasters caused by excessive mutation. The society depicted in Rebirth is not unlike the society described in Arthur Miller's The Crucible: bigoted, fearful, and punitive. The book makes a good scenario for demonstrating the mechanisms men employ in seeking to account for things that happen in the world. We would rather run the risk of being wrong in our explanation of why things happen, than not try to explain at all.

F-9 HISTORICAL BIBLIOGRAPHY

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GLOSSARY

ABSORPTION - the passage of a substance into or through another substance (see adsorption)

ADIABATIC PROCESS - changes in matter which take place without the transfer of energy

ADVECTION - the horizontal movement of a mass of air that causes changes in physical properties of the local environmental air

ADSORPTION - the attachment of a substance to the surface of a second substance which is in the solid or liquid phase

AEROSOL - a solid or liquid particle that may remain suspended in the atmosphere because of its size; generally refers to particles under 1 micron in diameter

AIR SHED - a geographic area that is assumed to share the same air

ALEUTIAN & ICELANDIC LOWS - the semi-permanent low pressure regions in the troposphere that are normally found over the Aleutian Islands and Iceland

ALVEOLI - the tiny air sacs at the end of the bronchioles of the lung, where oxygen and carbon dioxide trnasfer takes place

AMBIENT AIR - the surrounding air

BIOSPHERE - the part of the world in which life can exist

BRONCHIAL ASTHMA - an attack consisting of narrowing of the bronchioles, swelling or thickening of the mucous membrane, accompanied by wheezing or coughing

BRONCHIOLE - small branch of the bronchus

BRONCHUS - a major airway of the respiratory system

CILVA - hair-like cells that line the airways

CONVECTIVE MOTIONS - the transfer of masses of air, in the vertical, produced by thermal or pressure differences

CYCLONIC COLLECTOR - any of several mechanical devices that employ rotational motion to remove particles from an air stream

ECOSYSTEM - the functioning unit which comprises the physical environment and the ecological community

ELECTROMAGNETIC RADIATION SPECTRUM - the complete range of waves, commonly classified according to frequency and wave length, that transmits energy by radiation

EMPHYSEMA - a change in the lungs which results in a breakdown of the walls of the alvioli

ENTRAINMENT - the transport by mechanical means of foreign substance by the system under study

ENVIRONMENT - the composite of all external conditions and influences affecting the survival of an organism

EUTROPHY - bodies of water which are high in nutrients and low in oxygen content at the bottom and characterized by rapid algae growth

FAST BREEDER REACTOR - the apparatus in which nuclear fission takes place and fissionable byproducts are produced faster than consumed

FISSION - the splitting of large atomic nuclei into smaller nuclei(fission fragments), accompanied by the release of large amounts of energy

FLY ASH - the particle impurities exhausted into the atmosphere as a result of the burning of organic fuels

FRONTAL INVERSION - an inversion condition produced by the frontal temperature in the vertical

FUME - smoke vapor or gas produced by chemical reactions or the condensation of vapor

GLOBAL HEAT BALANCE - the accounting of what happens to the incoming and out going radiation of the earth-atmosphere system.

GROUND WATER - water which saturates a zone of earth below the surface and constantly seeps into streams and lakes

GROWTH RATE - equals birthrate minus deathrate

HEAT ISLAND EFFECT - the phenomenon of air circulation peculiar to cities

HORSE LATITUDES - either of the regions near 30° latitude characterized by high pressure, calms and light baffling winds

HYDROCARBONS - any of the family of compounds which contain carbon and hydrogen atoms in various combinations

HYGROSCOPIC - any particle that readily absorbs and retains moisture

IMPACTION - the forceful collision and lodging of airborne particles caused by horizontal movement of air masses

INVERSION - a layer of cool air trapped by a layer of warm air above it, preventing the lower layer of air from rising

ISOTHERMAL - points in the environment that are at the same temperature

LAPSE RATE - the rate of change of temperature with altitude

LATENT ENERGY - energy that is released or absorbed during a phase change

LEACH - to remove soluble components by use of an excess of solvent

LEE - the side that is sheltered from the wind

LIGHT PHASE (photosynthesis) - the segment of the photosynthetic process during which light energy is utilized to decompose the water molecule

MERIDIONAL PLANE - a plane perpendicular to a tangent plane at the earth's surface and containing a line of longitude

MESOSPHERE - a layer of atmosphere extending from the top of the stratosphere to an altitude of about 50 miles.

MILLIBAR - a unit of atmosphere pressure equal to 1/1000 of a bar (1013 mb= one atmosphere)

MILLIRAD - 1/1000 of a unit of measurement for ionizing radiation absorbed by man

MIXING DEPTH - the thickness of the sector of the atmosphere in which air rises from the earth's surface to the inversion

NITROGEN FIXATION - the conversion of free atmospheric nitrogen to nitrogen compounds primarily by action of soil bacteria

NITROGEN OXIDES - gases formed from atmospheric nitrogen and oxygen primarily under conditions of combustion at high temperature and high pressure

ORGRAPHIC - relating to mountains

OXIDATION - the formation of new substances by chemical reactions involving combination with oxygen

OZONE - a pungent, colorless, triatomic oxygen gas that is toxic and corrosive

PHOTOCHEMICAL - chemical changes brought about by the utilization of radiant energy

PLUME - the visual effluent from a stack

POLAR FRONT - the world's principal front betwwen the polar easterlies and the westerlies which causes much of the storminess of the temperate zone

PPM - parts per million; the number of parts of a given pollutant in a million parts of air

RECESSIVE GENES - a character factor which is masked by the dominant gene when both are present in an individual

SCRUBBER - a device that uses a liquid spray to remove particulate and gaseous pollutants from an air stream

SILVICULTURE - the development and care of forests

SMOKE - solid or liquid particles under 1 micron in diameter (a type of aerosol)

STABILITY - the atmospheric condition which exists when the temperature of the air increases rather than decreases with altitude

STEMATA - openings, largely on the underside of a leaf through which gases enter or leave the leaf

STRATOSPHERE - the layer of the atmosphere between the troposphere and mesosphere in which ozone is produced. Very little temperature change occurs and clouds of water are rare

TERPENE - a hydrocarbon found in and evaporated from the conifers

THERMAL CONDUCTION - the transfer of heat through or between substances which are in contact by the interaction of the particles which comprise the substances

THERMOSPHERE - the fourth layer of the atmosphere, between 48 and 360 miles, in which the temperature increases rapidly with height

THYROID - a gland which produces an iodine containing hormone that affects growth, development and the metabolic rate

TOPOGRAPHIC - relating to the configuration of a surface

TROPOSPHERE - the layer of atmosphere which encircles the earth from its surface to the height of about 5 miles at the poles and 10 miles at the equator

TURBULENCE - convictively produced air movement and mixing

ULTRAVIOLET RADIATION - radiation beyond the visible spectrum at its violet end (less energetic than x-rays)

VORTEX - a large mass of air having whirling or circular motion

WIND - the natural, horizontal movement of the air

Guide to Air Pollution Literature

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I. Ecology, Environment, and Man

The following books are intended to provide you with an ecological framework within which environmental problems, such as air pollution and its control, can be understood. Basic ecological principles are presented from a variety of perspectives. Intensive reading of one or two works may be more rewarding than skimming through many. Browse through several until you find an approach that is appealing - then dig in!

The books are divided into two groups. The first group deals with the ecological outlook applied to all living things. The second focuses on the ecology of man.

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Watts, Alan W. The Book; On the Taboo Against Knowing Who You Are. New York, Pantheon Books, 1966. 146 p.

Watts, Alan W. Does it Matter? Essays on Man's Relation to Materiality. New York, Pantheon Books,1970.

Wylic, Philip. The Magic Animal. Garden City, New York, Doubleday, 1968. 358 p.

Zipf, George K. Human Behavior and the Principle of Least Effort. New York, Hafner, 1949. 573 p.

II. Pollution and the Environmental Crisis

In recent years there has been a growing awareness of the threat to man's well-being and survival stemming from the accumulation of the wastes produced as by-products of his activities. In the minds of some, this threat has reached crisis proportions. The following works reflect this feeling of crisis and point out as well the interrelations of all environmental problems.

A. Books

Benarde, Melvin A. *Our Precarious Habitat*. New York, W.H. Norton, 1970. 362 p.

Blake, Peter. *God's Own Junkyard; The Planned Deterioration of America's Landscape*. New York, Holt, Rinehart, and Winston, 1964.

Bregman, Jack I. and Sergei Lenormand. *The Pollution Paradox*. New York, Spartan Books, 1966. 191 p.

Brown, Harrison S. *The Challenge of Man's Future.* New York, Viking Press, 1954.

Commoner, Barry.*Science and Survival*. New York, Viking Press, 1966. 150 p.

Cubbedge, Robert E. *The Destroyers of America.* New York, Macfadden-Bartell Corp., 1964.

Dansereau, Pierre M., ed. *Challenge for Survival: Land, Air, and Water for Man in Megalopolis*. New York, Columbia University Press, 1970. 235 p.

Dasmann, Raymond F. *The Destruction of California*. New York, Macmillan, 1965. 247 p.

De Bell, Garrett, ed. *The Environmental Handbook*. New York, Ballantine Books, 1970. 365 p.

De Vos, Anthony, *et. al.*, eds. *The Pollution Reader.* Montreal, Harvest House, 1968. 264 p.

Ehrlich, Paul R., *et. al*., *Ecocatastrophe.* San Francisco, City Lights, 1970.

Goldstein, Jerome. *Garbage as You Like It*. Emmaus, Pa., Rodale Books, 1969. 243 p.

Hay, John. *In Defense of Nature*. Boston, Little, Brown & Co., 1970.

Helfrich, Harold W., Jr., ed. *The Environmental Crisis; Man's Struggle to Live With Himself*. New Haven, Yale University Press, 1970. 187 p.

Herber, Lewis. *Crisis in Our Cities*. Englewood Cliffs, N.J., Prentice-Hall, 1965. 239 p.

Hocking, Brian. Biology or Oblivion: Lessons from the Ultimate Science. Cambridge, Mass., Schenkman, 1965.

Lawrence, R.D. The Poison Makers. Camden, N.J., Thomas Nelson & Sons, 1969. 160 p.

Laycock, George. The Diligent Destroyers. Garden City, N.J., Doubleday, 1970. 225 p.

Leinwand, Gerald. Air and Water Pollution. New York, Washington Square Press, 1969. 160 p.

Lillard, Richard G. Eden in Jeopardy; Man's Prodigal Meddling With His Environment: The Southern California Experience. New York Alfred A. Knopf, 1966. 338 p.

Linton, Ron M. Terracide; America's Destruction of Her Living Environment. Boston, Little, Brown and Co., 1970. 376 p.

McClellan, Grant S., ed. Protecting Our Environment. New York, H.W. Wilson Co., 1970. 218 p. (The Reference Shelf, Vol. 42, No. 1)

Marine, Gene. America The Raped; The Engineering Mentality and the Devastation of a Continent. New York, Simon and Schuster, 1969 312 p.

Marquis, Ralph W., ed. Environmental Improvement: Air, Water, and Soil. Washington, D.C., U.S. Dept. of Agriculture, Graduate School, 1966. 105 p.

Mellanby, Kenneth. Pesticides and Pollution. London, Collins, 1967. 221 p.

Odum, Eugene P., et. al., The Crisis of Survival. Glenview, Ill., Scott, Foresman and Co., 1970.

Osborn, Fairfield. Our Plundered Planet. Boston, Little, Brown and Co., 1948.

Osborn, Robert. Mankind May Never Make It. New York, New York Graphic Society, 1968.

Packard, Vance. The Waste Makers. New York, David McKay, 1960. 306 p.

Perry, John. Our Polluted World; Can Man Survive? New York, Franklin Watts, 1967. 213 p.

Rienow, Robert and Leona T. Moment in the Sun: A Report on the Deteriorating Quality of the American Environment. New York, Dial Press, 1967.

Rodale, Jerome I. Our Poisoned Earth and Sky. Emmaus, Pa., Rodale Books, 1964. 735 p.

Roueche, B, What's Left: Reports on A Diminishing America: Boston, Little Brown & Company, 1969.

Stewart, George R. Not So Rich as You Think. Boston, Houghton-Mifflin, 1968. 248 p.

Still, Henry. The Dirty Animal. New York, Hawthorne Books, 1967. 298 p.

Udull, Stewart L. The Quiet Crisis. New York, Holt, Rinehart, and Winston, 1963. 209 p.

Vogt, William. The Road to Survival. New York, William Sloane Association, 1948.

Wilson, Billy R., ed. Environmental Problems: Pesticides, Thermal Pollution and Environmental Synergisms. Philadelphia, Lippincott, 1968.

B. Articles

Over the years there has been a steady increase in concern with environmental problems, such as air pollution, as reflected in the number of articles published in popular journals. However, until only recently, these problems usually been dealt with independently of one another. The decade of the sixties marks a significant turning point in that not only did the number of articles on these problems show a marked increase, but the problems began to be viewed as interrelated.

These are several indexing services that are useful in locating articles on pollution and the environment. These are in Section I accompanied by a set of terms under which relevant articles are listed.

There are several magazines which present news and articles on environmental problems for the layman and student. These are listed in Section 2.

In the spring of 1972 when public concern with environmental problems reached a peak, several magazines instituted regular sections on the environment. These are listed in Section 3. In addition, some magazines published special issues as noted in Section 4.

Section I. Indexes

New York Times Index

Air Pollution
Environment
Pollution
U.S. - Environmental Problems
Water Pollution

Readers Guide to Periodical Literature

Air Pollution
Environment (al)
Industry and the Environmental Movement
Pollution
Water Pollution

Public Affairs Information Service Bulletin

Air Pollution
Ecology
Environment
Human Ecology
Man-Influence of Environment
Pollution
U.S. -[Environmental Agencies]
Water Pollution

Section 2. Magazines Presenting News and Articles on Environmental Polluting Problems.

Air & Water Conservation News
Air & Water News
Bulletin of the Atomic Scientists
Chemical & Engineering News
Clean Air & Water News
Conservation Foundation Letter
Environment
Environmental Jonrnal
Environmental Monthly

Section 3. Magazines Having Regular Sections on the Environment.

Time - "Environment" - beginning with February 16, 1970 issue.
Science News - "Environmental Sciences" beginning with February 28 , 1970 issue.
Saturday Review - "Environment & the Quality of Life" beginning with March 7, 1970 issue.

Section 4. Special Issues Devoted to the Environment.

Newsweek - "The Ravaged Environment". January 26, 1970.
Fortune - "Environment: A National Mission for the Seventies" February 1970 issue.
Progressive - "The Crisis of Survival" April 1970 issue.
Ramparts - "Ecology Special" May 1970 issue.

III. General Works on Air Pollution and Its Control

A. Introductory Works

American Association for the Advancement of Science. Committee on Science in the Promotion of Human Welfare: Air Conservation Commission. Air Conservation; Report... Washington, D.C., 1965. 335 p. $8.00 (A.A.A.S. Publication No. 80).

Battan, Louis J. The Unclean Sky: A Meteorologist Looks of Air Pollution. Garden City, N.Y., Anchor Books, 1966. 141 p. pap. $1.25. (Science Study Series, No. S46)

Bryson, Reid A. and Kutzbach, John E. Air Pollution. Washington, D.C. Association of American Geographers, 1968. 42 p. (A.A.G., Commission on College Geography, Resource Paper No. 2)

Carr, Donald E. The Breath of Life. New York, W.H. Norton, 1965. 175 p. $4.95.

Corman, Rena. Air Pollution Primer. New York, National Tuberculosis and Respiratory Disease Association, 1969. 104 p. $1.25.

Edelson, Edward. The Battle for Clean Air. New York, Public Affairs Committee, 1967. 28 p. 25¢ (Public Affairs Pamphlet, No. 403)

Edelson, Edward and Warshofsky, Fred. Poisons in the Air. New York, Pouhet Books, 1966. 160 p. $1.00.

Esposito, John C. Vanishing Air. New York, Grossman Publ. 1970 $7.95; pap. 95¢ (Ralph Nader's Study Group Reports)

Farber, Seymour M., and Wilson, Roger H.L., eds. The Air We Breathe: A Study of Man and His Environment. Springfield, Ill., C.C. Thomas, 1961. 414 p. $4.00.

Lewis, Howard R. With Every Breath You Take: New York, Crown Publ., 1965. 322 p. $5.00.

Mills, Clarence A. This Air We Breathe. Boston, Mass., Christopher Publ. House, 1962. 172 p. $4.00.

Nadler, Allen C., et al. Air Pollution. New York, Scientists' Institute for Public Information, 1970. 28 p. $1.00 (Environmental Workbook).

III. General Works on Air Pollution and Its Control

A. Introductory Works (continued)

Rossano, A.T., Jr., ed. Air Pollution Control: Guidebook for Management. Stanford, Connecticut, Environment Research and Applications Inc., Environmental Science Service Division, 1964. 214 p. $15.00.

Scorer, Richard S. Air Pollution. New York, Pergamon Press, 1968. 151 p. $7.50; pap. $4.50 (flexi-cover)

Sproul, Wayne T. Air Pollution and Its Control. Jericho, N.Y., Exposition Press, 1970. 106 p. $4.00.

B. Prophecies and an Account of an Air Pollution Episode in London

Lodge, James P., comp. The Smoake of London; Two Prophecies: Famifugum; or, The Inconvenience of the Aer and Smoake of London Dissipated, by John Evelyn; and The Doom of London, by Robert Barr. Elmsford, N.Y., Maxwell Reprint, 1969. 56 p. $5.00.

Wise, William. Killer Smog; The World's Worst Air Pollution Disaster. Chicago, Rand McNully, 1968. 181 p. $5.95.

C. Textbooks

Faith, William L. Air Pollution Control. New York, Wiley, 1959. 259 p. o.p.

Gilpin, Alan. Control of Air Pollution. New York, Plenum Press, 1963. 514 p. $25.00.

Meetham, A.R. Atmospheric Pollution: Its Origins and Prevention. 3rd ed. Rev. by D.W. Bottom and S. Cayton. Oxford, Pergamon Press, 1964. 301 p. $10.00.

Stern, Arthur C., ed. Air Pollution. 2nd ed. New York, Academic Press, 1968. 3 Vols. $95.00.

Thring, Meredith W., ed. Air Pollution. London, Butterworths, 1957. 248 p. o.p.

World Health Organization. Air Pollution. New York, Columbia University Press, 1961. 442 p. o.p. (W.H.O. Monograph Series, No. 46).

III. General Works on Air Pollution and Its Control

D. Pamphlets

Air Pollution...A National Problem. Washington, U.S. Government Print.Off., 1962 50 p. (PHS Publication No. 975).

Air Pollution: The Facts. New York, National Tuberculosis and Respiratory Disease Association, 1970. free.

The Air We Live In; The Health Effects of Air Pollution. Washington, U.S. Government Print. Off., 1959. (PHS Publication No. 640) free.

The Battle for Clean Air, by Edward Edelson. New York, Public Affairs Press, 1967. 28 p. (Public Affairs Pamphlet No. 403) 25¢.

Clean Air for Your Community, Washington, D.C. Supt. of Docs, U.S. Government Print.Off., 1969. 12 p. 25¢.

Clearing the Air; A Layman's Guide to Atmospheric Purity by Wallace West, New York, American Petroleum Institute, Committee on Public Affairs, 1963. free.

The Effects of Air Pollution. Washington, Supt. of Docs, U.S.G.P.O., 1967, 18 p. (PHS Publication No. 1556, Rev. 1967) 25¢.

Everyday Facts About Air Pollution. Washington, Manufacturing Chemists Association, 1966. free.

The High Cost of Air; Economic Effects of Air Pollution. Washington, Supt. of Docs, U.S. 1958. 5 p.

Physician's Guide to Air Pollution. Chicago, Ill., Americas' Medical Association, 1968. 20 p. free.

Primer on Air Pollution. 2nd ed. New York, Mobil Oil Co., n.d., 20 p. free.

Smog-The Silent Killer; 1967 Biennial Report. Los Angeles, California State Motor Vehicle Control Board. 1967.

Some Health Aspects of Air Pollution. New York, Dept. of Air Resources, City of New York, 1969.

Sources of Air Pollution and Their Control. Washington. Supt. of Docs, U.S.G.P.O. 1966(PHS Publication No. 1548)

III. General Works on Air Pollution and Its Control

D. Pamphlets (continued)

A Study of Pollution - Air; A Staff Report to the Committee on Public Works. U.S. Senate. Washington, U.S.G.P.O. 1963 (Committee Print 88th Congress, 1st Session), 62 p.

Take Three Giant Steps to Cleaner Air; Washington, D.C. U.S.G.P.O. 1966.

Together We Can Check the Blight of Air Pollution; A Partnership for Local Control. Florham Park, N.J., John Wood Company, Air Pollution Control District, n.d. 20p.

No Laughing Matter; The Cartoonist Focuses on Air Pollution. Washington, D.C. U.S.G.P.O., 1966, 70¢.

Our Polluted World; American Educational Publications, 1968, 35¢.Junior High.

IV. Scientific and Technical Aspects of Air Pollution and Its Control

The literature on the scientific and technical aspects of air pollution and its control is too vast to be listed here. Since 1955, when the Air Pollution Control Association began to issue abstracts (see *APCA Abstracts*, below) more than 13,000 articles and monographs have been abstracted. Fortunately, there are several excellent bibliographic tools which permit easy identification of material on a given topic.

Any search of the literature should begin with the three-volume textbook edited by Arthur C. Stern (*Air Pollution*. 2nd edition, New York, Academic Press, 1968). Although it is several years old, it provides a comprehensive summary of the literature on the scientific and technical aspects of air pollution and its control.[1] Individual chapters consist of review articles written by many of the leading experts in the field. Each article can serve as an introduction to any particular topic as well as a guide to the literature up to about 1968. Author and subject indexes are included in each volume.

For more recent works on all aspects of air pollution and its control, the previously mentioned *APCA Abstracts* is an excellent guide. Issued monthly as a supplement to the *Journal of the Air Pollution Control Association*, it includes abstracts of articles appearing in over 600 journals as well as preceedings of conferences, collected works and individual monographs. Abstracts are numbered consecutively since 1955 and include a complete citation (using standard abbreviations for periodical titles) and an abstract or summary prepared either by the author or by the staff of the Air Pollution Control Association. The July issue includes a Title Index for the previous volume (June-May);the August issue includes an Author Index; and the September issue includes a Journal Index with full titles and publisher's addresses.

The way in which these two tools may be used together is shown by the table below in which the parts of Stern are matched with the corresponding sections of APCA Abstracts . The numbers before the titles of these sections correspond to their order in APCA Abstracts..

Stern - Air Pollution	APCA Abstracts
Volume I. Air Pollution and Its Effects	1. General Aspects
Part 1. Air Pollution (Phenomena)	2. Emission Sources
Part 2. Air Pollution Meteorology	3. Atmospheric Interactions
Part 3. Effects of Air Pollution	6. Effects - Human Health 7. Effects - Plants and Livestock 8. Effects - Materials 9. Effects - Economic
Volume II. Analysis, Monitoring, Surveying	
Part 4. Analysis of Pollutants	4. Measurement Methods 13. Basic Sciences and Technologies
Part 5. Air Quality and Meteorological Monitoring	10. Air Quality Measurements 13. Basic Sciences and Technologies
Part 6. Source Measurements and Community Survey	2. Emission Sources 4. Measurement Methods
Volume III. Sources of Air Pollution and Their Control	
Part 7. Sources of Air Pollution	2. Emission Sources
Part 8. Control Methods and Equipment	5. Control Methods 13. Basic Sciences and Technologies
Part 9. Air Pollution Control	11. Legal and Administrative Aspects 12. Standards and Criteria
[not dealt with in Stern]	14. Social Aspects

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1. There are separate chapters on the legal and administrative aspects of air pollution and its control, but economic, political, and social aspects are dealt with only in passing or not at all.

Several other abstracting and indexing services should be mentioned also:

1. Air Pollution Abstracts. Issued monthly by The Warren Spring Laboratory, Stevenage, England, it may pick up titles from British and other European countries that are missed by APCA Abstracts. Organization is similar to that of APCA Abstracts. However, since they photoreproduce abstracts from original sources (as well as those of APCA Abstracts!), the variations in typography make them difficult to read.
2. Air Pollution Bibliography. This appears periodically in issues of the journal Atmospheric Environment; An International Journal, published in England. It consists of selected titles from APCA Abstracts without the abstracts. The organization of the titles in APCA Abstracts is retained. It can serve as a quick finding checklist for retrospective searches only, since there is a delay of several months between the time they are abstracted in APCA Abstracts and listed here.
3. Air Pollution Titles; A Guide to the Current Air Pollution Literature. Issued bimonthly by the Center for Air Environment Studies, The Pennsylvania State University, University Park, Pennsylvania, this publication is a "Key-Word-in-Context (KWIC) Index" to articles on air pollution. It is intended as a current awareness tool for research workers rather than as a retrospective searching tool, The November - December issue cumulates the titles for the whole year and can be purchased separately.
4. NAPCA Abstract Bulletin. Published monthly by the Air Pollution Technical Information Center of the National Air Pollution Control Administration, this publication is intended as a current awareness bulletin providing abstracts from "over 1000 domestic and foreign journals..., from governmental and industrial report literature, and from preprints." It duplicates in scope the APCA Abstracts with perhaps more items from the

technical report literature made available through the Clearing house for Federal Scientific and Technical Information, the main source of publications produced by government and government sponsored research. Having begun publication in 1970 it can serve as a guide to the most recent literature to supplement APCA Abstracts. Its organization is that of APCA Abstracts.

A nymber of other indexing and abstacting services may also be searched for more specialized topics. Those include the following"

1. Applied Science and Technology Index. (Wilson, New York)
2. Battelle Technical Review. (Battelle Memorial Institute, Columbus, Ohio)
3. Bibliography of Agriculture. (National Library of Agriculture, Washington,D.C.)
4. Biological Abstracts. (Biological Abstracts Inc., Philadelphia, Penn.)
5. Chemical Abstracts. (American Chemical Society, Easton, Pennsylvania)
6. Engineering Index. (Engineering Index, Inc., New York)
7. Environmental Effects on Materials and Equipment; Abstracts. (National Academy of Sciences - National Research Council, Division of Chemistry and Chemical Technology, Prevention of Deterioration Center, Washington, D.C.) monthly
8. Index Medicus. (National Library of Medicine, Bethesda Maryland)
9. Industrial Hygiene Digest. (Industrial Hygiene Foundation, Pittsburgh,Pa.)
10. International Aerospace Abstracts. (American Meteorological Society, Washington, D.C.)
11. Journal of the Iron and Steel Institute. (Iron and Steel Institute, London, England)
12. Meteorological and Geoastrophysical Abstracts. (Americal Meteorological Society, Washington, D.C.)
13. Nuclear Science Abstracts. (Division of Technical Institute, A.E.C.Oak Ridge, Tennessee)
14. Public Health Engineering Abstracts. (National Center for Urban and Industrial Health, U.S., P.H.S. Cincinnati, Ohio)

15. Scientific and Technical Aerospace Reports.(NASA, Washington, D.C.)

16. Technical Abstract Bulletin.(DDC, Defense Supply Agency, Cameron Station Alexandria, Virginia)

17. U.S. Government Research and Dev. Repts.(CFSTI, Washington, D.C.)

18. Biological and Agricultural Index. (H.W.Wilson Co., New York)

19. Geophysical Abstracts. (U.S. Government Printing Office, Washington,D.C.)

20. Occupational Safety and Health Abstracts. (International Safety and Health Information Centre, Geneva, Switzerland)

21. Monthly Catalog of U.S. Government Publications. (U.S. Government Printing Office, Washington, D.C.)

22. Pandex Current Index of Scientific and Technical Literature. (C.C.M. Information Sciences, Inc., New York)

23. Science Citation Index.(Institute for Scientific Information, Philadelphia, Pennsylvania).

24.Search: Chemical Materials & Products Division. (Compendium Publisher's International Corporation, Fort Lee, N.J.)

25. Wild Life Review. (Patuxent Wildlife Research Center, Laurel, Md.)

26. Government-Wide Index to Federal Research and Development Reports. (U.S. Department of Commerce, Clearinghouse for Scientific and Technical Information, Springfield, V..) Indexes unclassified reports produced as a result of government-sponsored research and development as they are abstracted in items numbered 13, 15, 16, and 17 above.

Handbooks and Manuals.

Air Pollution Control Association. *Technical Manuals*. Nos. 1-4, Pittsburgh, Pa., 1963-1968.

American Industrial Hygiene Association. *Air Pollution Manual*. two parts, Detroit, Michigan, 1960, 1968.

Los Angeles County Air Pollution Control District. *Air Pollution Engineering Manual*. compiled and edited by John A. Danielson. Washington, D.C., U.S. Govt. Printing Office, 1967. (Public Health Service Publication No. 999-AP-40).

Magill, Paul L., *et al*., *Handbook of Air Pollution; Training Program*. Washington, D.C., U.S. Govt. Printing Office, 1968. (Environmental Health Series; Air Pollution; Public Health Service Publication No. 999-AP-44).

Journals.

The following journals regularly include articles on the scientific and technical aspects of air pollution:

Air Pollution Control Association Journal. 1951-Monthly. Individuals $15, Institutions $50. Air Pollution Control Association, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213.

American Industrial Hygiene Association Journal. 1940- Six issues/year. $15. American Industrial Hygiene Association, 25711 Southfield Road, Southfield, Michigan 48075.

Analytical Chemistry. 1929. Monthly. Membership; non-members $5. American Chemical Society, 1155 16th Street, N.W.Washing,D.C.20006.

Archives of Environmental Health. 1950. Monthly. $12. American Medical Association, 535 North Dearborn Street,Chicago,Illinois 60610.

Atmospheric Environment; An International Journal. 1967-Bi-monthly. Institutions $50. Pergamon Press, 44-01 21st Street, Long Island City, New York 11101.

Atmospheric Pollution Bulletin. 1932. (In 3 Sections: Section 1 and 3 Monthly; Section 2 Semi-monthly) Warren Spring Laboratory, Gunnels Wood Road, Stevenage, England.

Bulletin of Environmental Contamination and Toxicology. 1966-Bi-monthly. $20. Springer-Verlag New York, Inc., 175 Fifth Avenue, New York 10010.

Chemical Engineering. 1902. Fortnightly. $4. McGraw-Hill, Inc. 330 West 42nd Street, New York, New York 10036.

Chemical Engineering Progress. 1947. Monthly. Free to Members; Others $25. American Institute of Chemical Engineers, 345 East 47th Street, New York, New York 10017.

Combustions. 1929. Monthly. $4. Combustion Publication Company, Inc., 277 Park Avenue, New York, New York 10017.

Contamination Control. 1962- Monthly. $5. (American Association for Contamination Control) Blachment Publication Company, Inc., 1605 Cahnenga Boulevard, Los Angeles, California 90028.

Environmental Research. 1967- Bi-monthly. $25. Academic Press, Inc., 111 Fifth Avenue, New York, New York 10003.

Environmental Science and Technology. 1967- Monthly. Non-members $7. American Chemical Society, 1155 Sixteenth Street, N. W., Washington, D.C. 20036.

Health Physics. (American Health Physics Society). 1958. Monthly. $60. Pergamon Press, Inc., Maxwell House, Fairview Park, Elmstord, New York 10523.

Institute of Fuel Journal. 1926. Monthly. Membership; Non-members 150s. Institute at Fuel, 18 Devonshire Street, Portland Place, London WI, England.

Nature. 1869. Weekly. $39. Mucmilland and Company, Ltd., St. Martin's Street, London WL2, England.

Oil and Gas Journal. 1902. Weekly. $9. Petroleum Publication Company, 211 S. Cheyenne Avenue, Tulsa, Oklahoma 74101.

Paper Trade Journal. 1972. Weekly $5. Lochwood Trade Journal Company, 551 Fifth Avenue, New York, New York 10017.

Pollution Atmospherigne. 1959. Quarterly. 40F. Societe de la Rerne, 21 rue Marillo, 75-Paris (8e), France.

Power. 1882. Monthly. $5. McGraw-Hill, Inc., 330 West 42nd Street, New York, New York 10036.

Rubber World. 1889. Monthly. $7. Bill Brothers Publication Corp., 630 Third Avenue, New York, New York 10017.

Science. 1880. Weekly. $12. American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W. Washington, D.C. 20005.

Science Journal. 1965. Monthly. $10.50. Associated Ilitte Press, Ltd., Dorset House, Stamford Street, London SEI, England.

Smokeless Air. 1929- Quarterly. Non-members $1.40. National Society for Clean Air, Field House, Breams Building, London EC4, England.

Stuub. (English Translation) Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia 22151.

Talanta. 1958. Monthly. $90. Pergamon Press, Inc., Maxwell House, Fairview Park, Elmstord, New York 10523.

TAPPI. 1949. Monthly, Membership. Technical Association of The Pulp and Paper Industry, 360 Lexington Avenue, New York, New York 10017.

Technology Review. 1899. Monthly (no. 5-July) $9. Alumni Association, Massachusetts Institute of Technology, Room E19-30, Cambridge, Mass. 02139.

Wasser, Luft and BeTrieb. 1957. Monthly.DM.51.20. KG Krausskopt-Verlag, Lessingstrasse 12-14, 65 Mainz, Germany.

Work - Environment - Health. Institute of Occupational Health, Helsinki, Finland.

WHO Bulletin. 1947/8- Monthly. $23. World Health Organization, Palais des Nations, Geneva, Switzerland.

IV. Scientific and Technical Aspects of Air Pollution and Its Control (continued)

The following list of books is selective and includes mainly books in print and available from trade publishers. Some government publications are also included. Technical reporst have for the most part been excluded. They may be found through *APCA Abstracts* or other abstracting and indexing services mentioned above.

A. Geochemistry and Geophysics of the Earth

Advances in Geophysics. Ed. by H.E. Landsberg, and others, 14 volumes, New York, Academic Press, 1952-1970.

Ahrens, Louis H. *The Distribution of Elements in Our Planet*. New York, McGraw-Hill, 1965.

Ahrens, Louis H., *et al.*, eds. *The Physics and Chemistry of the Earth*. 7 volumes, Oxford, Pergamon Press.

American Chemical Society. *Chemistry and the Environment:The Solid Earth, The Oceans, The Atmosphere*. Washington, D.C. 1967.

Bates, David R. *Planet Earth*. 2nd revised edition, Oxford, Pergamon Press, 1964.

Cailleux, A. *Anatomy of the Earth*. New York, McGraw-Hill, 1968.

Carrington, Richard. *Guide to Earth History*. New York, New American Library.

De Witt, Cecile M., *et al.*, *Geophysics:The Earth's Environment.*, New York, Gordon and Breach, 1963.

Dury, G.H. *The Face of the Earth*.New York, Penguin Books, 1959.

Ernst, W. *Earth Materials*. Englewood Cliffs, New Jersey, Prentice-Hall, 1969.

Fraser, Ronald G.J. *Habitable Earth*. New York, Basic Books, 1965.

Gamow,George A. *A Planet Called Earth*. New York, Viking Press, 1963.

Haber, Heinz. *Our Blue Planet; The Story of the Earth's Evolution*.New York, Scribners, 1969.

Hurley, Patrick M., ed. *Advances in Earth Science*. Cambridge, Mass., M.I.T. Press.

Jeffreys, Sir Harold. *The Earth, Its Origin, History and Physical Constitut .* 5th edition, Cambridge, England, Cambridge University Press, 1970.

Krauskopf, Konrad B. *Introduction to Geochemistry*. New York, McGraw-Hill, 1967.

Mason, Brian. *Principles of Geochemistry*. 3rd edition, New York,Wiley,1966.

A. (continued)

Odishaw, Hugh, ed. *Research in Geophysics*. 2 volumes, Cambridge, Mass., M.I.T. Press.

Ordway, Richard J. *Earth Science*. Princeton, N.J., Van Nostrand, 1966.

Rumney, George R. *The Geosystem; Dynamic Integration of Land, Sea, and Air*. Dubugue, Iowa, W.C. Brown, 1970.

Runcorn, S.K.,ed. *International Dictionary of Geophysics*. 2 volumes. New York, Pergamon Press, 1968.

Runcorn, S.K.,ed. *Methods and Techniques in Geophysics*. 2 volumes, New York, Wiley (Interscience), 1960, 1966.

Runcorn, S.K.,ed. *Progress in Physics and Chemistry of the Earth*. New York, Pergamon Press.

Scientific American, Editions of. *Planet Earth*. New York, Simon and Schuster, 1957.

Smith, Frederich G. *Physical Geochemistry*.Reading, Mass., Addison-Wesley, 1963.

Spar, J. *Earth, Sea, and Air: A Survey of the Geophysical Sciences*. Reading, Mass., Addison-Wesley, 1962.

Spilhaus, Athelstan. *Satellite of the Sun*. New York, Atheneum, 1964.

Strahler, Arthur N. *Earth Sciences*. New York, Harper-Row, 1963.

Sutton, Graham, ed. *The World Around Us:From Sea Level to Ionosphere*. New York, Collier Books.

True, W.P., ed. *Earth and Life*. New York, Simon and Schuster.

Wedepohl, Karl H.,ed. *Handbook of Geochemistry*. New York, Springer-Verlag, 1969, 2 volumes.

B. The Atmosphere and Atmospheric Phenomena

Barry, R.G. *Atmosphere, Weather, and Climate*. New York, Holt, Rinehart and Winston, 1969.

Batton, Louis J. *Radar Observes the Weather*. Garden City, New York, Doubleday, 1962.

Blumenstock, David I. *The Ocean of Air*. New Brunswick, N.J., Rutgers University Press, 1959.

B. (continued)

Brooks, C.E.P. *Climate Through the Ages*. New York, Dover, 1970 (c. 1949).

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